NATIONAL BOARD FOR TECHNICAL EDUCATION
PLOT 'B' BIDA ROAD, P. M. B. 2239, KADUNA

CURRICULUM AND COURSE SPECIFICATION FOR

HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY

(PHYSICS WITH ELECTRONICS OPTION)

JUNE 2021

GENERAL INFORMATION ON HND SCIENCE LABORATORY TECHNOLOGY

(PHYSICS WITH ELECTRONICS OPTION) PROGRAMME

1.0 TITLE OF THE PROGRAMME: The title of the programme is Higher National Diploma in Science Laboratory Technology (Physics with Electronics Option)

2.0 GOAL AND OBJECTIVES OF THE PROGRAMME

Goal:
This programme is designed to produce graduates with knowledge and skills in practical application of Physics, Electronics and Instrumentation.

Objectives:
On completion of the Programme, the graduates should be able to:

1) Manage Physics/Electronics laboratory;
2) Use the concept of Physics to explain the behavior of particles at atomic and sub-atomic levels;
3) Apply the concept of wave nature of light in optical systems;
4) Apply principles of measurement in electrical/electronic systems;
5) Carry out solar system installations;
6) Apply principles of Acoustics in the design of buildings and appliances;
7) Predict reliability of systems;
8) Select materials and electronic components for design, construction and fabrication purposes;
9) Analyze and troubleshoot electrical/electronic circuits;
10) Develop programmes for the construction of simple automatic systems;
11) Apply knowledge of electromagnetism in electrical appliances and telecommunication systems; and
12) Relate forces to motion and stability.

3.0 ENTRY REQUIREMENTS

The general entry requirements for the HND programme include:

a. National Diploma (ND) in Science Laboratory Technology with a minimum of lower credit pass (CGPA of 2.50 and above) obtained from an NBTE accredited programme plus a minimum of one year Post-ND cognate work experience in Science Laboratory Technology

b. In exceptional cases, the ND diplomates with a pass grade (CGPA 2.0 - 2.49) in the ND examination that had two or more years of cognate work experience, may be considered for admission into the programme. However, the number of such candidates should not be more than 10% of the total student intake in each class.

4.0 STAFFING REQUIREMENT

4.1 Headship of the Department

The HOD should be at least a Senior Lecturer who has a minimum of second degree in Physics or Electronics. S/he should have at least 10 years cognate experience and must be registered with the relevant professional body.

4.2 Core Teaching Staff

At the point of mounting the programme, there should be a minimum of four Lecturers who should be of the rank of Lecturer II and above, with minimum qualification of first degrees (BSc or B.Tech) in Physics, Electronics or Science Laboratory Technology (Physics).

4.3 Technical Staff

These are technically qualified staff not involved in direct lecturing/instructing, but who provide vital and indispensable services in laboratories, workshops, studios, use of machinery and equipment, farms and other field facilities

4.3.1 Technologist

Technologist should possess HND or equivalent qualification in Physics/Electronics.

4.3.2 Technician

Technicians should possess ND or equivalent qualification in Science Laboratory Technology.

4.3.3 Assistant/Attendants

Assistants/attendants should be attached to each facility to ensure its proper upkeep. The Assistants should possess SSCE (Science-based), while the Attendants should possess Junior Secondary School Certificate.

5.0 CAREER/ACADEMIC PROSPECTS

On successful completion of the programme, the graduands may be employable as technologists in:

a) Academic Laboratories;
b) Oil and Gas Industry;
c) Manufacturing Industry;
d) Telecommunication Industry;
e) Research Laboratories;
f) Laser-Optics Industry;
g) Nuclear Power Plants;
h) Textile/Industrial Design;
i) Radiation Protection;
j) Gas Power Plants;
k) Solar Photovoltaic and Solar Thermal Industry;
l) Laboratories/Medical Instruments Maintenance;
m) Design and Construction of Laboratories for Institutions, Industries etc;
n) Vending of Laboratory Instruments;
o) Recording and Transmission Studios;
p) Meteorological Stations;
q) Environmental Science Facilities; and
r) Medical Imaging Facilities.

6.0 DURATION OF PROGRAMME

The duration of the programme is two academic sessions consisting of four semesters of 17 weeks each.

7.0 CURRICULUM

7.1 The curriculum of the programme consists of four main components. These are:

a. General Studies/Education
b. Foundation Courses.
c. Professional Courses
d. Project.

7.2 The General Education component shall include courses in:

English Language, Entrepreneurship and Citizenship Education. The General Education component shall account for not more than 10-15% of the total contact hours for the programme.

Foundation courses include courses in Mathematics and Computer Science. The number of hours for the courses may account for about 10-15% of the total contact hours.

Professional courses are core courses of the programme that give the student the theory and professional skills he/she needs to practice his/her field of calling at the Technologist level. These may account for between 70-80% of the contact hours.

8.0 CURRICULUM STRUCTURE

The structure of the programme consists of four semesters of classroom, laboratory and workshop activities in the institution. Each semester shall be of 17 weeks duration made up as follows:

a. 15 weeks of teaching, i.e. instruction, practical exercise, quizzes, test, etc; and
b. 2 weeks for examinations and registration.

9.0 ACCREDITATION

The National Board for Technical Education shall accredit the programme before the diplomates can be awarded the Higher National Diploma certificates. Details about the process of accrediting a programme for the award of the Higher National Diploma are available from the office of the Executive Secretary, National Board for Technical Education, Plot "B", Bida Road, P.M.B. 2239, Kaduna, Nigeria.

10.0 AWARD OF HIGHER NATIONAL DIPLOMA

10.1 Conditions for the award of Higher National Diploma include the following:

a. Satisfactory performance in all prescribed course work, which may include class work, tests, quizzes.
b. Workshop practice, laboratory work and fieldwork.
c. Satisfactory performance at all semester examinations.
d. Satisfactory completion of final year project work.

Normally, for all courses including final year project work, continuous assessment contributes 40%, while semester examinations and project reports are weighted 60% to make a total of 100%. For Seminar presentation, Continuous assessment contributes 30 %, while Seminar reports are weighted 70 % to make a total of 100 %.

10.2 Higher National Diploma should be awarded in four classes:

a. Distinction - CGPA of 3.50 and above
b. Upper Credit - CGPA of 3.0 - 3.49
c. Lower Credit - CGPA of 2.50 - 2.99
d. Pass - CGPA of 2.00 - 2.49.

10.3 Grading of Courses: Courses shall be graded as follows:

MARKED RANGE	LETTER GRADE	WEIGHTING
75 % and above	A	4.00
70 % – 74 %	AB	3.50
65 % – 69 %	B	3.25
60 % – 64 %	BC	3.00
55 % – 59 %	C	2.75
50% – 54 %	CD	2.50
45 % – 49 %	D	2.25
40 % – 44 %	E	2.00
Below 40 %	F	0.0

11.0 GUIDANCE NOTES FOR TEACHERS

11.1 The new curriculum is drawn in unit courses. This is in keeping with the provisions of the National Policy on Education which stress the need to introduce the semester credit units which will enable a student who so wishes to transfer the units already completed in an institution of similar standard from which he/she is transferring.

11.2 In designing the units, the principle of the modular system by product has been adopted, and each of the professional modules, when completed provides the student with technologist operative skills, which can be used for employment purposes or self-reliance.

11.3 As the success of the credit unit system depends on the articulation of programmes between the institutions and industry, the curriculum content has been written in behavioral objectives, so that it is clear to all the expected performance of the student who successfully completed some of the courses or the diplomates of the programme. This is slight departure in the presentation of the performance based curriculum which requires the conditions under which the performance is expected to be carried out and the criteria for the acceptable levels of performance. It is a deliberate attempt to further involve the staff of the department teaching the programme to write their own curriculum stating the conditions existing in their institution under which performance can take place and to follow that with the criteria for determining an acceptance level of performance.

The Academic Board of the institution may vet departmental submission on the final curriculum. Our aim is to continue to see to it that a solid internal evaluation system exists in each institution for ensuring minimum standard and quality of education in the programmes offered throughout the Polytechnic system.

11.4 The teaching of the theory and practical work should, as much as possible, be integrated. Practical exercises, especially those in professional courses and laboratory work should not be taught in isolation from the theory. For each course, there should be a balance of theory to practical in the ratio of 50:50 or 60:40 or the reverse. **In each semester, the practical components for all courses that have practical works have been put into a single practical course with separate course code and title. Thus, as the practical works are carried out alongside the theory, the continuous assessment (CA) for each practical work of all applicable courses will be compiled under each practical course in each semester. Furthermore, there will be practical tests and semester examination for each practical course in each semester.**

12.0 PRACTICAL LOGBOOK

A personal Log-book to be kept by each student shall contain all the day-to-day, weekly summary, and semester summary of all the practical activities from day one to the end of the programme. This is to be checked, marked, endorsed and recorded by the lecturers/technologists concerned at the end of every week.

13.0 FINAL YEAR PROJECT

Final year students in this programme are expected to carry out a project work. This could be on individual basis or group work of not more than two students per group, but reporting must be undertaken individually. The project should, as much as possible incorporate basic elements of design, drawing and complete fabrication of a marketable item or something that can be put to use. Project reports should be well presented and should be properly supervised.

The departments should make their own arrangement of schedules for project work.

HND I SEMESTER 1

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH	Prerequisite
1	COM 301	Computer Programming	2	-	2	2	
2	GLT 301	Laboratory Management	1	-	2	1	
3	GLT 302	Instrumentation (General)	2	p	2	2	
4	PYE 311	Modern Physics	2	P	2	2	
5	PYE 312	Material Science	2	P	2	2	
6	PYE 313	Electric Circuit Theory	2	P	2	2	
7	PYE 314	Electromagnetism I	2	P	2	2	
8	PYE 315	Introduction to Solid State Physics	1	-	2	1	
9	PYE 316	Physics/Electronics Practical I	-	10	5	10	
10	MTH 311	Advanced Algebra	1	-	1	1	
11	GNS 301	Use of English III	1	-	1	1	
		TOTAL	16	10	23	26	

HND I SEMESTER 2

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH	Prerequisite
1	PYE 321	Thermodynamics	2	-	2	2	
2	PYE 322	Electromagnetism II	2	**P**	2	2	PYE 314
3	PYE 323	Analogue Electronics	2	**P**	2	2	
4	PYE 324	Telecommunication Principles	2	P	2	2	
5	PYE 325	Physical Optics	2	P	2	2	
6	PYE 326	Quantum Mechanics	2	**-**	2	2	
7	PYE 327	Physics/Electronics Practical II	-	8	4	8	PYE 316
8	MTH 312	Advanced Calculus	1	**-**	1	1	MTH 311
9	GNS 402	Literary appreciation and Oral Composition	1	**-**	1	1	
			14	8	18	22	

HND II SEMESTER 1

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH	Prerequisite
1	PYE 411	Advanced Equipment Maintenance and Repairs	2	P	2	2	
2	PYE 412	Instrumentation	2	P	2	2	
3	PYE 413	Radio Communication Principles	2	-	2	2	
4	PYE 414	Computational Physics	1	-	1	1	
5	PYE 415	Digital Electronics	2	P	2	2	
6	PYE 416	Applied Solar Energy	2	P	2	2	
7	PYE 417	Acoustics	1	-	1	1	
8	PYE 418	Physics/Electronics Practical III	-	8	4	8	
			12	8	16	20	

HND II SEMESTER 2

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH	Prerequisite
1	PYE 421	Control Systems	2	P	2	2	
2	PYE 422	Microelectronic Systems	2	P	2	2	
3	PYE 423	Equipment Reliability	2	-	2	2	
4	PYE 424	Physics/Electronics Practical IV	-	4	2	4	
5	PYE 425	Seminar			2		
6	PYE 426	Project			4		
			6	4	14	10	

HND I SEMESTER 1

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Modern Physics	**Code:** PYE 311	**Contact Hours:** 4 Hours
Credit Unit: 2 Units	**Pre-requisite**	**Theoretical:** 2 hours/week
Year: 1	**Semester:** First	**Practical:** 2 hours/week

Course main Goal: This course is designed to provide students with the basic knowledge of the principle and experimental facts underlying quantum mechanics and atomic theory.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Comprehend the experimental basis of quantum theory
2.0 Interpret the basis of the atomic model
3.0 Appreciate the wave particle nature of matter
4.0 Use spectroscopy in the analysis of atomic transition
5.0 Comprehend the use of microscopy in Nano science
6.0 Appreciate the nature and application of X-rays
7.0 Appreciate the general features of nuclear reactions

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Modern Physics			**Code:** PYE 311		**Credit units:** 2 units	
Course Specification: Theoretical contents			**Practical Code:** PYE 316		**Credit Hour:** 2 Hours	
1.0 **General Objective 1.0** Comprehend the experimental basis of quantum theory						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Explain the blackbody radiation.	Lecture to Discuss, with	Pasco radiation sensor, Pasco	Determine radiation from objects at	Students should determine	Direct the students to explain the

	1.2 Account for the empirical data on blackbody radiation. 1.3 Describe the resemblance of the emission curves with those of the Maxwell speed distribution. 1.4 Explain the Rayleigh – Jeans theory 1.5 State the reason(s) for the failure of the Rayleigh-Jeans approach (the ultraviolet catastrophe). 1.6 Explain the Wien's radiation law. 1.7 Describe classical theory of black body. 1.8 Paraphrase Planck's quantum theory of radiation.	examples the experimental basis of quantum theory. Describe resemblance of the emission curves with those of the Maxwell speed distribution and the Rayleigh – Jeans theory Explain the reason(s) for the failure of the Rayleigh-Jeans approach (the ultraviolet catastrophe). Explain classical theory of black body. Explain Planck's quantum theory of radiation.	thermal radiation cube, three multimeters, Window glass. Stefan-Boltzmann lamp, Power supply and meter stick	certain temperatures, and take measurements testing the Stefan-Boltzmann law in high- and low-temperature ranges; measure the inverse-square law for thermal radiation	thermal radiation rates from different surfaces and take measurements testing the Stefan-Boltzmann law in high- and low-temperature ranges; measure the inverse-square law for thermal radiation	principles of black body radiation and its classical theory. Ask the students to explain the Rayleigh – Jeans theory and the reason(s) for the failure of the Rayleigh-Jeans approach (the ultraviolet catastrophe).
Objectives 2.0 Interpret the atomic model						
	2.1 Explain the Rutherford's nuclear model of the atom. 2.2 Explain Rutherford's		Diffraction grating (transmission type), meter stick; optical rails (2); quantitative	Determine and observe absorption, emission and transmission spectra	Students should determine and observe absorption,	Instruct the students to describe the different models of the atom.

	scattering and its conclusions. 2.3 State the limitations of Rutherford's model of atom, 2.4 Explain [i] electron orbits, and [ii] atomic spectra. 2.5 Explain the Bohr model of atom. 2.6 Explain Bohr's model energy, radius and velocity. 2.7 Explain quantization in the Bohr model. 2.8 Explain emission of radiation in Bohr's theory. 2.9 Explain the failures of the Bohr model. 2.10Explain Einstein theory of photoelectric effect. 2.11Derive an expression of work function for photoelectric effect. 2.12Account for the Compton effect and Compton scattering.	Lecture students to discuss the various atomic models with relevant class examples.	spectroscopes (4); LED circuit board; adjustable voltage dc power supply; demo AS-13 flame test kit; Spectronic 200 spectrometer; 100 mL graduated cylinders (2); concentrated food colors in dropper bottles (red, yellow, green, blue); and incandescent light bulb fixture	of a variety of sources; Evaluate the energy-frequency relation to determine Planck's constant; Determine the wavelengths and energies of some of the electronic transitions of the Balmer series for hydrogen.	emission and transmission spectra of a variety of sources, Evaluate the energy-frequency relation to determine Planck's constant; Determine the wavelengths of light expected for specific electronic transitions of hydrogen. Note: [i] Supervise the practical. [ii] Group the students for the purpose of the practical. [iii] Demonstrate the experiment for the students before allowing	

					them to work in groups.	
General Objectives 3.0 Appreciate the wave particle nature of matter						
	3.1 Describe Wave and Particles. 3.2 Explain the concept of a matter wave. 3.3 Explain wave-particle duality: light 3.4 Explain De-Broglie Hypothesis 3.5 Explain the concept of a matter wave. 3.6 Write down the de Broglie equation relating momentum to wave number (or to wavelength or frequency). 3.7 Account for the Davisson-Germer experiment and how it confirmed the wave nature of electrons. 3.8 Describe de Broglie's explanation of Bohr's orbital angular momentum quantization postulate as a result of a standing electron wave.	Explain the wave particle nature of matter with relevant class examples. - De-Broglie Hypothesis -the concept of a matter wave. - Davisson-Germer experiment and how it confirmed the wave nature of electrons. - de Broglie's explanation of Bohr's orbital angular momentum quantization postulate as a result of a standing electron wave and Complementarity Principle.	-Photoelectric apparatus with a phototube, Light Emitting Diodes (LEDs) of several colors, two digital meters, Photocathode /ammeter apparatus, mercury arc lamp and power supply, red laser, green laser pointer, digital voltmeter and color filters Lecture notes, reference texts and	Demonstrate that light can behave as a particle and determine Planck's constant.	Demonstrate that light behaves like a particle when it interacts with matter, such as electrons on a metal surface. Estimate the value of Planck's constant h.	Ask students to differentiate between the behavior of wave and particle matter. Direct the students to explain photoelectric effect and Einstein theory of photoelectric effect and photoelectric effect, using Wien's black body. Ask the students to explain photoelectric effect and Einstein theory of photoelectric effect and photoelectric effect, using Wien's black body.

	3.9 Explain Complementarity Principle. 3.10 Describe photoelectric effect. 3.11 Explain Einstein theory of photoelectric effect. 3.12 Account for Einstein's explanation of the photoelectric effect, using Wien's black body. 3.13 Derive expression work functions for photoelectric effect. 3.14 Account for the Compton effect and Compton scattering. 3.15 Define Heisenberg uncertainty principle.	Explain photoelectric effect and Einstein theory of photoelectric effect, using Wien's black body. Drive expression of work functions for photoelectric effect, account for the Compton effect and Compton scattering and define Heisenberg uncertainty principle.	materials.			Direct students to derive expression work functions for photoelectric effect, account for the Compton effect and Compton scattering and define Heisenberg uncertainty principle
General Objectives 4.0 Use spectroscopy in the analysis of the atomic transitions						
	4.1 Explain spectroscopy and outline its theoretical foundation. 4.2 Explain how the frequency of any line of the spectrum is proportional to the difference between	Lecture Discuss the concept of spectroscopy in the study of atoms Explain the characteristics of spectra lines	Zeeman effect apparatus	Demonstrate the experimental procedure used to observe and quantify the Zeeman components for one or more spectral lines, measure the splitting and	Demonstrate the experimental procedure used to observe and quantify the Zeeman components for one or more spectral lines,	State the principles and applications of atomic spectroscopy. List types of spectra and identify the appearance of each.

	the values of the energies of the two states of the atom emitting and absorbing the radiation 4.3 List the types of spectra describing the physical appearance of each spectra line. 4.4 Explain the behavior of the lines when the emitting atoms are subjected to external electric and magnetic fields (Zeeman's effect) 4.5 Explain Zeeman's effect 4.6 Explain how to measure magnetic field intensity using Zeeman's effect 4.7 Explain the orbital, spin, and magnetic numbers of the atom. 4.8 Describe the Stern-Gerlach experiment to demonstrate electron spin 4.9 Solve numerical problems involving the energies of a spectrum, the	Describe normal and anomalous Zeeman's effect Calculate some simple problems involving the frequency, wavelength etc. between two energy levels. Explain the behavior of the lines when the emitting atoms are subjected to external electric and magnetic fields (Zeeman's effect) Explain Zeeman's effect Explain how to measure magnetic field intensity using Zeeman's effect	Lecture notes, reference texts and materials.	compare the results with theoretical predictions.	measure the splitting and compare the results with theoretical predictions, for the students	Direct the students to calculate some simple problems involving the frequency, wavelength etc. between two energy levels. Ask the students to explain how to measure magnetic field intensity using Zeeman's effect and explain the orbital, spin, and magnetic numbers of the atom.

	wavelength, frequency and the wave number between two energy levels.					
General Objectives 5.0 Comprehend the use of microscopy in Nano science.						
	5.1 Describe electron microscopy and name four kinds of electron microscopes. 5.2 Explain microscopy technique and its role in Nano-scale Science 5.3 Explain the advancement of electron microscopy techniques with respect to nanoparticles and flavivirus research. 5.4 Explain the basic principles and application of [i] Atomic force microscopy, AFM [ii] Scanning Electron microscopy, SEM [iii] Transmission electron microscopy, TEM 5.5 Name the parts and	Lecture Discuss with illustrations the concept of microscopy technique in the study of Nano-Science. Explain the basic principles and application of [i] Atomic force microscopy, AFM [ii] Scanning Electron microscopy, SEM [iii] Transmission electron microscopy, TEM Name the parts and probe of each microscopy	Text books Internet Classroom Resources Charts/Pictures Lecture notes, reference texts and materials.			Teacher guide students to identify types of microscopes to enable students appreciate the role of each in Nano-science research. Instruct the students to explain the basic principles and application of Atomic force microscopy, AFM Scanning Electron microscopy, SEM, Transmission electron microscopy, TEM Ask the students to name the parts and

	probe of each microscopy mentioned in (5.4) 5.6 Explain the image that can be seen using different kinds of electron microscopy.	explained in (5.4) Explain the image that can be seen using different kinds of electron microscopy.				probe of each microscopy and explain the image that can be seen using different kinds of electron microscopy
General Objectives 6.0 Appreciate the nature and application of X-rays						
	6.1 Describe the production of X-rays, explaining its nature, properties and uses. 6.2 Explain how the intensity of an X-ray beam is reduced upon passing through matter 6.3 Derive an expression for the intensity, I, of a beam after passing through a thickness X; ie $I = I_o e^{-\mu x}$ 6.4 Define (i) linear absorption coefficient (ii) mass absorption coefficient of absorption. State the relationship between the coefficients. 6.5 Explain how secondary emission occurs when X-rays are absorbed.	Lecture students to Describe what happens when an X-ray beam is passed through body. Explain as stated in 6.4 Discuss secondary emission in X-radiation Lecture Explain coherent and	Text books Internet Classroom Resources Charts/Pictures Lecture notes, reference texts and materials.			Describe the production of X-rays. Explain the effect of X-ray when incident on planes in a crystal. Describe the different types of emission resulting from X-ray production, State Mosley's law and with the aid of a diagram the characteristic features of Mosley's law. State the relationship between the accelerating voltage

	6.6 Describe the different types of emission resulting from X-ray production, 6.7 State Mosley's law. 6.8 Describe with the aid of a diagram the characteristic features of Mosley's law. 6.9 State the relationship between the accelerating voltage and the quality of X-rays. 6.10 Explain what happens when a parallel beam of X-rays falls on given family of planes in a crystal. 6.11 State and derive Bragg's law. 6.12 Describe how to determine X-ray absorption coefficient.	Incoherent scattering. Discuss the characteristic of spectrum produced by an X-ray Describe Mosley's law using Diagram different types of emission resulting from X-ray production, Mosley's law. Describe with the aid of a diagram the characteristic features of Mosley's law.	Lecture notes and reference texts.			and the quality of X-rays. Describe with the aid of a diagram the characteristic features of Mosley's law.
General Objective 7.0 Appreciate the general features of nuclear reactions						
	7.1 Analyze nuclear structure, constituents and properties, (isotopes, isobars, binding energy, stability).	Lecture Discuss the concept of nuclear reactions.	Tuning – eye vacuum tube (6AF6), Air-core solenoid, variable dc power supply (250 V dc), ac power supply	Determine the Charge to mass ratio (e/m) of the electron	The student should determine the Charge to mass ratio (e/m) of the electron	Direct the students to state the conservation laws of nuclear reactions and describe the general features of

	7.2 Explain the general features of nuclear reactions. 7.3 Explain the conservation laws of nuclear reactions. 7.4 Derive an expression for the Q-value of a nuclear reaction. 7.5 Define a nuclear cross-section. 7.6 Derive an expression for nuclear cross-section. 7.7 Calculate the expectation function of a given reaction. 7.8 Explain nuclear reactions [i] general features, and [ii] kinematics of the compound nucleus, 7.9 State Breit-Wigner formula, nuclear fusion and f1ssion.	Discuss nuclear fuels. Calculate cross-section from supplied information Discuss nuclear fuels Categorize nuclear reactors in terms of coolant, conversion ratio and neutron energies.	(6.3 V ac), dc power supply (12 V dc), rheostat, dc ammeter (0 to 5A), connecting wires, Vernier calipers and meter ruler, wooden dowels of different diameter			nuclear reactions. Direct the students to calculate the expectation function of a given reaction and explain nuclear reactions [i] general features, and [ii] kinematics of the compound nucleus Ask the students to state Breit-Wigner formula, nuclear fusion and f1ssion

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Material Science	**CODE:** PYE 312	**Contact Hour:** 4 Hours/Week
Credit Unit: 2	**Pre-requisite**	**Theoretical:** 2 Hours/Week
Year: 1	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: This course is designed to provide students with the knowledge of basic structure and properties of materials with specific attention to alloys and metals.

On completion of this course, the student should be able to:

1.0 Comprehend the classification of materials
2.0 Translate the relevant electrical properties of materials
3.0 Recognize the magnetic properties of materials
4.0 Appreciate the thermal properties of materials
5.0 Recognize the optical properties of materials
6.0 Appreciate the science of Nano materials

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS OPTION)						
Course Title: Material Science			**Code:** PYE 312		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 316		**Contact Hours:** 2 Hours	
General Objective 1.0 Comprehend the classification of materialsAppreciate the science of Nano materials						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Specific Learning Objective					
	1.1 Explain the meaning of materials	Differentiate materials with regards to their	Solid copper wire coil, Liquid nitrogen with	Determine the effect of temperature on	The students should determine the	Differentiate materials with regards to their

	science and engineering. 1.2 Explain the need for the study of materials science and engineering. 1.3 Explain the various classifications of materials: metals, ceramics, polymers composites and other advanced materials such as semiconductors, biomaterials, smart materials and nano materials. 1.4 State the properties of materials: physical, mechanical, electrical and magnetic. 1.5 Explain the need for modern materials 1.6 Explain the	chemical constituent, physical characteristics and internal structure arrangement. State the properties of materials: physical, mechanical, electrical and magnetic. Explain the need for modern materials	dewar, dry ice, ice water bath, room temp water bath, hot plate/ boiling water bath, multimeter, thermocouple, electric furnace, silicon wafer and wire leads Lecture note with reference text and materials	electrical conductivity of metals and semiconductors.	effect of temperature on electrical conductivity of metals and semiconductors	chemical constituent, physical characteristics and internal structure arrangement. Direct the students to state the properties of materials: physical, mechanical, electrical and magnetic. Ask students to explain the need for modern materials

	bases of properties of materials and selection of materials.					
General Objectives 2.0 Translate the relevant electrical properties of materials						
	2.1 Explain electrical conductivity. Describe the energy band structures in solids. 2.2 Explain conduction in terms of bands and atomic bonding models. 2.3 Describe the electrical characteristics of commercial alloys. 2.4 Explain the temperature dependence of electrical conduction in Semiconductors. 2.5 State factors affecting carrier mobility in semiconductor	Lecture Describe electrical properties of various materials	Solid copper wire coil, liquid nitrogen with Dewar, dry ice, ice water bath, room temp water bath, hot plate/boiling water bath, multimeter, thermocouple, electric furnace, silicon wafer and wire leads. Set of parallel plate capacitors (Diameter = 26 cm), high voltage power supply (0-10kV), a 10 MΩ resistor, reference capacitor (220nF), universal	Determine the effect of temperature on electrical conductivity of metals (copper) and semiconductors (Silicon). Determine the dielectric Constant of different materials	The students should determine the effect of temperature on electrical conductivity of metals and semiconductor s The student should determine the dielectric Constant of different materials	Direct the students to explain the different types conduction in terms of bands Direct the students should determine the dielectric Constant of different materials

	devices. 2.6 Explain dielectric materials and dielectric strengths 2.7 Explain Ferro electricity and Piezoelectricity		measuring amplifier, voltmeter, dielectric materials (Plastic and glass plates), connecting cables, adapters, and T-connectors			
General Objectives: 3.0 Recognize the magnetic properties of materials						
	3.1 Explain magnetism and 3.2 Explain Bohr magneton 3.3 Explain Magnetic dipoles 3.4 Explain Magnetic field and derive an expression for magnetic flux density. 3.5 Explain magnetic susceptibility. 3.6 State and explain the various types of magnetism [i] Dia-magnetism [ii] para-magnetism [iii] Ferro-	Lecture Describe magnetic properties of various materials Explain the effect of temperature on magnetic materials and also explain magnetic domain and hysteresis	Strong neodymium magnet 50 grade. Dimension 50*20*10 mm, refrigerator for cooling the magnet, electricity and some electric component to heat up the magnet, a set of electromagnet (having resistance of 700 Ohm), dry ice for cooling electromagnet, gloves and glasses for safety purposes, electricity measuring tool, Gauss meter for measuring the	Determine the effect of Temperature on Electric Current, Magnets and Electromagnet.	Direct the student to determine the effect of Temperature on Electric Current, Magnets and Electromagnet.	Ask the student to determine the effect of Temperature on Electric Current, Magnets and Electromagnet. Instruct the students to Explain the effect of temperature on magnetic materials and also explain magnetic domain and hysteresis

	magnetism [iv] anti-ferromagnetism [v] Ferri-magnetism. 3.7 Explain the effect of temperature on magnetic materials. 3.8 Explain magnetic domain and hysteresis 3.9 Explain magnetic storage 3.10 Explain soft, semi-hard and Hard magnetic materials.		power of magnet and also of electromagnet and boiled water (one tub).			
General Objective: 4.0 Appreciate the thermal properties of materials						
	4.1 Explain specific heat capacity and specific latent heat. 4.2 Explain thermal expansion/contraction 4.3 Explain the coefficient of thermal expansion. 4.4 Explain thermal	Lecture Describe thermal properties of various materials Explain thermal	Linear-expansion apparatus, steam generator, breaker, 100 ^{o}C thermometer, rubber tubing, metal rods of aluminum, iron, copper, brass, and steel.	Determine the coefficients of expansion of several metals. Determine the specific heat	The students Should determine The coefficient of expansion of several metals. Direct the	Direct students to explain the difference between thermal expansion/ contraction

	expansion in crystalline and semi-crystalline materials 4.5 Explain thermal expansion in non-crystalline (amorphous) materials: the glass transition. 4.6 Explain thermal conductivity 4.7 Explain melting and boiling points 4.8 Explain thermo-elastic properties of materials. 4.9 Explain thermal stress 4.10 Explain specific heat capacity and specific latent heat. 4.11 Explain thermal expansion/contraction 4.12 Explain the coefficient of thermal expansion. 4.13 Explain thermal expansion in	conductivity, melting and boiling points. Explain thermo-elastic properties of materials, thermal stress, specific heat capacity and specific latent heat. Explain thermal expansion/contraction, conductivity, thermal expansion in non-crystalline (amorphous) materials: the glass transition. Explain melting, boiling points, thermo-elastic properties of materials and thermal stress	Newton's law of cooling apparatus, copper calorimeter with a wooden lid, stirrer, an open double – walled vessel, two Celsius thermometers(each with least count 0.5 ^{o}C or 0.1 ^{o}C), stop clock/watch, heater/burner, liquid (water), clamp stand, two rubber stoppers with holes, strong cotton thread, beaker, copper calorimeter with stirrer, double-walled enclosure with cold water between the walls, thermometer (0.1^{o}C), stop clock/watch, heater/burner, and rubber stoppers. Beaker of 1 litre (mixture of ice	capacity of a liquid using the cooling method. Determine the specific heat capacity of a bad conductor.	students to determine the specific heat capacity of a liquid using the cooling method. Direct the students to determine the specific heat capacity of a bad conductor.	Short verbal questions on thermo-elastic properties of materials, thermal stress, specific heat capacity and specific latent heat. Give numerical examples. Direct students to explain thermal expansion/contraction, conductivity, thermal expansion in non-crystalline (amorphous) materials: the glass transition. Instruct students to Explain melting, boiling points, thermo-elastic properties of materials and thermal stress

	crystalline and semi-crystalline materials 4.14 Explain thermal expansion/contraction 4.15 Explain thermal expansion in non-crystalline (amorphous) materials: the glass transition. 4.16 Explain thermal conductivity 4.17 Explain melting and boiling points 4.18 Explain thermo-elastic properties of materials. 4.19 Explain thermal stress		and water at 0 ^{o} C), ice, thermometer (1 ^{o} C interval), test tube (diameter about 25 mm), tube should be fitted with a cork drilled centrally to take the thermometer and slot for stirrer, stopwatch (0.1 s), Vernier calipers, double stirrer, and retort stand.			
General Objective: 5.0 Recognize the optical properties of materials						
	5.1 Explain electromagnetic radiation. 5.2 Explain material -light interaction 5.3 Classify optical materials 5.4 Explain optical properties of [i]	Lecture Describe optical properties of various materials and explain reflection, refraction, diffraction, [interference and polarization Discuss the following	Lee's apparatus and the experimental specimen in the form of a disc, two thermometers, stop watch, weighing balance, special lamp	Determine thermal conductivity of a bad conductor (glass) in form of a disc using Lee's method.	Direct the students to determine thermal conductivity of a bad conductor (glass) in form of a disc using Lee's method.	Ask students to describe optical properties of various materials and explain reflection, refraction, diffraction, [interference and polarization. Instruct the students

	metals and [ii] non-metals. 5.5 Explain [i] reflection, [ii] refraction, [iii] diffraction, [iv] interference and [v] polarization. 5.6 Explain absorption and transmission. 5.7 Explain absorption mechanism 5.8 Describe the following optical phenomena: [i] luminescence (photo-luminescence, cathode-luminescence, and electro-luminescence,) [ii] thermal emission [iii] photo-conductivity 5.9 Describe the following [i] laser, optical fibres	optical phenomena: luminescence (photo-luminescence, cathode-luminescence, and electro-luminescence,) thermal emission photoconductivity	stand, boiler and heater. Lecture notes with reference texts and materials.			to discuss the following optical phenomena: luminescence (photo-luminescence, cathode-luminescence, and electro-luminescence,) thermal emission photoconductivity

	5.10 Explain the various types of optical fibres 5.11 State the properties of optical fibres.					
General Objective: 6.0 Appreciate the science of Nano materials						
	6.1 Describe nano materials. 6.2 Explain the methods of synthesis of nano particles: [i] chemical methods and [ii] pulsed laser methods. 6.3 Explain the size dependence of properties of materials. 6.4 Explain the methods of measuring these properties. 6.5 Explain particle size determination. 6.6 Explain microscopy techniques – transmission electron microscopy and	Lecture Describe nano materials and explain the methods of synthesis Explain microscopy techniques – transmission electron microscopy and scanning microscopy. Explain spectroscopic techniques –IR, Raman spectroscopy, and magnetic resonance.	Lecture notes with reference texts and materials. -do-			Direct students to describe nano materials and explain the methods of synthesis given several examples. Ask students to explain microscopy techniques – transmission electron microscopy and scanning microscopy. Instruct the students to explain spectroscopic techniques –IR, Raman spectroscopy, and magnetic resonance.

	scanning microscopy. 6.7 Explain spectroscopic techniques –IR, Raman spectroscopy, and magnetic resonance.					

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Electric Circuit Theory	**Code:** PYE 313	**Contact Hours:** 4 Hours/Week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: This course is intended to enable the student acquire basic knowledge of electric circuit theory.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Outline basic laws and generalized methods of circuit analysis.
2.0 Outline Network theorems and their application to dc Electrical circuit.
3.0 Use ac theory and its application to electrical solve circuit problems
4.0 Appreciate the sinusoidal steady- state analysis
5.0 Appreciate the ac power analysis
6.0 Determine ac resonance
7.0 Translate the concept of three phase ac circuits

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Electric Circuit Theory			**Code:** PYE 313		**Credit Unit:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 316		**Contact Hours:** 2 Hours	
8.0 General Objective 1.0: Outline basic laws and generalized methods of circuit analysis. **Translate the concept of three phase ac circuits**						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Basic Laws 1.1 State Ohm's Law. 1.2 State Kirchhoff's voltage and current laws. 1.3 Calculate voltage drops and total current at a point in complete circuit applying Kirchhoff's laws. 1.4 Explain Series Resistors and Voltage Division 1.5 Explain Parallel Resistors and Current Division 1.6 Explain the term: Nodes, Branches, and Loops 1.7 Describe simultaneous equations in circuit analysis 1.8 Explain Branch-current analysis 1.9 Explain Mesh analysis (general approach) 1.10Evaluate Super-mesh current analysis	State Ohm's law and Kirchhoff's law. Solve numerical problems in Ohm's law and Kirchhoff's law. Derive equations for series and parallel arrangement of resistors. Numerical solve, problems Lecture with worked	dc circuit training system, set of wires, dc Power supply, digital A.V.O. meter (1) Universal circuit board, (2) D-cell batteries (1.5 V), (2) battery holders, (4) alligator clips, (1) DMM, (5) resistors: (R1 = 10 Ω, resistor R2 = 12 Ω, resistor R3 = 15 Ω, resistor	Investigate Kirchhoff 's laws practically Apply Kirchhoff's rules for circuits to a two-loop circuit to determine the three currents in the circuit	The students should be asked to perform the experiment to investigate Kirchhoff 's laws practically Direct students to apply Kirchhoff's rules for circuits to a two-loop circuit to determine the three currents in the circuit and the electric	Assign numerical problems involving computation of Kirchhoff's voltage and current laws, series resistors and voltage division. Assign problems on Branch-current analysis, Mesh analysis, Super-mesh current, Nodal analysis, bridged networks,

	1.11Evaluate Mesh analysis (format approach) 1.12Evaluate Nodal analysis (general approach) 1.13Evaluate Nodal analysis (format approach) 1.14Evaluate bridged networks 1.15Identify the Wye and Delta network transformations. 1.16 Recognize the conversion of Delta to Wye and Wye to Delta networks.	examples. State applications, give and solve problem using Mesh analysis. Lecture with worked examples.	r4 = 18 Ω and resistor R5 = 22 Ω). `	and the electric potential differences around each loop.	potential differences around each loop.	Assign problems on Wye and Delta network transformation, conversion of Delta to Wye and Wye to Delta networks.
General Objectives 2.0 Outline basic laws and generalized methods of circuit analysis.						
	Network Theorems 2.1 Explain linearity property 2.2 Explain source transformation 2.3 State superposition theorem and explain the application of superposition theorem. 2.4 Calculate the current in any branch of a network by applying the superposition theorem. 2.5 State Thevenin's	Statement of super position with solved numerical examples.	**Recognize Network theorems and their application to dc Electrical circuit.**	**Recognize Network theorems and their application to dc Electrical circuit.**	Direct the students to verify the superposition theorem for the given circuit.	Direct the students to solve various problems on superposition theorem.

	theorem. 2.6 Explain the application of Thevenin's theorem. 2.7 Replace any circuit by the Thevenin's equivalent circuit. 2.8 Calculate the following: parameters in any branch of a network applying Helmholtz – Thevenin's theorem; [a] current [b] internal impedance [c] potential difference across the branch terminals. 2.9 State Norton's theorem 2.10Explain the application of Norton's theorem. 2.11Calculate the following parameter in any branch of a network applying Helmholtz – Norton's theorem; [a] the voltage across any branch of the network. [b] Internal shunt admittance of the network looking into the branch terminals. 2.12 State [i] Maximum power transfer theorem [ii] Millman's theorem (parallel – generated theorem). [iii]	Lecture Solve numerical problems applying superposition theorem. Lecture with solved examples. Solve numerical problems. Apply Norton's theorem in the solution of circuit problems. Lecture Solve numerical examples. Discuss the applications.			Direct the students to investigate Thevenin's and Norton's theorem practically. Direct the students to investigate maximum power transfer theorem practically. Direct the students to	Direct the students to solve various problems on Thevenin's and Norton's theorem. Ask the students to solve various problems on Thevenin's and Norton's theorem. Ask the students to

	Substitution theorem [iv] Reciprocity theorem. 2.13 Explain the application of theorems above. 2.14 Solve problems on network circuits by applying the theorems above.	Give examples using the theorem in 2.12			investigate reciprocity theorem practically.	solve various problems on reciprocity theorem
3.0 Use ac theory and its application to electrical solve circuit problems						
	Sinusoids and Phasors 3.0 Explain Sinusoids and Phasors. 3.1 Convert the polar form of ac signal to j notation. 3.2 Use j oprator to Subtract, add, multiply and divide phases. 3.3 Draw phase diagrams to scale for ac circuits, i.e. series and parallel. 3.4 Explain, with the aid of phasor diagrams, the current and voltage relationship in [i] inductive circuits and [ii] capacitive circuits. 3.5 Explain Phasor Relationships for Circuit Elements [i] impedance [ii] admittance 3.6 Distinguish between inductive and capacitive	Lecture Solve numerical problems showing the conversions. Draw phase diagrams to scale for ac circuits, i.e. series and parallel and explain, with the aid of phasor diagrams, the current and voltage relationship in inductive circuits	Power supply module EMS 8821, ac voltmeter module EMS 8426, ac current meter module EM.S 8428, resistance module EMS 8311, inductance module EMS 8321, capacitance module EMS 8321 Lecture notes, reference texts and	Determine the phasor relationship between voltage and current in a single-phase ac circuit.		Direct students to solve various phasor problems Direct the students to draw phase diagrams to scale for ac circuits, i.e. series and parallel and explain, with the aid of phasor diagrams, the current and voltage relationship in

	reactances. 3.7 Explain, with the aid of phasor diagrams, the current and voltage relationship in series L-C-R circuit. 3.8 Explain Kirchhoff's laws in the frequency domain. 3.10 Explain Impedance combination 3.11 Explain [i] Phase-Shifters and [ii] ac bridges. 3.12 Define [i] series resonance [ii] parallel resonance. 3.13 Sketch the curve of I against f (I = current; f = frequency) for [i] series circuit [ii] parallel circuit	and capacitive circuits. Explain Kirchhoff's laws in the frequency domain, impedance combination phase-shifters and ac bridges. Solve numerical example	materials. Lecture notes, reference texts and materials.			inductive circuits and capacitive circuits. Instruct students to explain Kirchhoff's laws in the frequency domain, impedance combination phase-shifters and ac bridges. Solve numerical examples.
9.0 **General Objectives 4.0** Use ac theory and its application to electrical solve circuit problems						
	Circuit theorems in ac analysis 4.1 Explain superposition theorem as applied to ac circuits with ac sources and reactive components. 4.2 Explain Thevenin's theorem as applied to ac circuits 4.3 (i) Describe Thevenin's	Lecture with solved examples Derive Thevenin's and Norton's theorem as	Lecture notes, reference texts and materials.			Direct the students to derive Thevenin's and

	equivalent circuit (ii) obtain the Thevenin's equivalent ac voltage source (iii) obtain the Thevenin's equivalent impedance. 4.4 Explain theorem as applied to ac circuits. 4.5 Explain maximum power transfer theorem 4.6 Explain maximum power transfer theorem. 4.7 Determine the value of load impedance for which maximum power is transferred. 4.8 Explain the following theorems: (i) Millman's Theorem; (ii) Substitution Theorem; and (iii) Reprocity Theorem.	applied to ac circuits and Show the circuit for equivalent voltage and equivalent impedance for both theorems. Solved examples. Explain maximum power transfer theorem and determine the value of load impedance for which maximum power is transferred.	741 op amp, oscilloscope, 10 turn potential divider, any five (at least) of 1 k, 5 k, 9 k, 10 k, 47 k, 90k, 100 k, 900 k, and 10 M resistors, five each of 1 pm, 5 N, and 10N capacitors	Determine the characteristics of an operational amplifier	Ask the students to determine the characteristics of an operational amplifier	Norton's theorem as applied to ac circuits and Show the circuit for equivalent voltage and equivalent impedance for both theorems. Solved examples. Ask students to explain maximum power transfer theorem and determine the value of load impedance for which maximum power is transferred.
General Objectives 5.0 Appreciate the ac power analysis						
	5.1 Explain the apparent and reactive power. 5.2 Determine power in ac circuit involving [i] resistive circuit [ii] inductive circuit [iii] reactive circuit [iv] capacitive circuit 5.3 Define [i] apparent power [ii] reactive power	Explain power in ac circuits Define the following	Digital Storage, oscilloscope (DSO) - NV6514 Kit	Determine the transient response of a series RC circuit and understand the time constant concept with dc Power Supply.	Direct the students to determine the transient response of a series RC circuit and understand the time constant concept with	Ask the students to solve various numerical problems on ac power circuits. Direct the students to define the

	[iii] true power [iv] complex power. 5.4 Explain maximum average power transfer 5.5 Explain effective or rms value 5.6 Explain the conservation of ac power. 5.7 Define power factor and explain the significance of power factor. 5.8 Explain what is meant by the power triangle. 5.9 Explain power-factor correction. 5.10 Explain the applications of ac power.	apparent power, reactive power, true power and complex power. Solve numerical examples. Define power factor and explain its significance.	Digital Storage Oscilloscope (DSO)	Determine the transient response of a series RL circuit and understand the time constant concept with ac Power Supply.	ac Power Supply. Direct the students to determine the transient response of a series RL circuit and understand the time constant concept with ac Power	following apparent power, reactive power, true power and complex power. Solve numerical examples. Instruct students to define power factor and explain its significance.
General Objectives 6.0 Determine ac resonance						
	6.1 Define [i] series resonance [ii] parallel resonance. 6.2 Sketch the curve of I against f (I = current; f = frequency) for [i] series circuit [ii] parallel circuit. 6.3 Determine in terms of L and C the resonant frequency, f_o, of an ac circuit, where L is inductance and C is capacitance. 6.4 Determine the inductance and the	Sketch curves and explain significance Lecture with solved examples.	Function generator (capable of 20 V, variable frequency), oscilloscope, inductor: (300) mH, capacitor: (0.001) μF, resistor: (500) Ω.	Investigate resonance in RLC networks by determining the theoretical parameters of series and parallel networks, and comparing the theoretical results to experimental results.	Direct the students to investigate resonance in RLC networks by - determining the theoretical parameters of series and parallel networks, - comparing the theoretical results to experimental	Direct the students to solve various numerical problems on ac resonance circuits.

	effective series resistance of an inductor in a series resonant circuit. 6.5 Sketch the curve of impedance (Z) against frequency (f) for [i] series circuit [ii] parallel circuits. 6.6 Define Q - factor (i.e. Q = Quality) for [i] series connection [ii] parallel connection. 6.7 Calculate the resonant frequency and Q - factor of a series $L-C-R$ circuit. 6.8 Define bandwidth for: [i] series connection [ii] parallel connection. 6.9 Calculate the following parameters in parallel $L-C-R$ circuits with known Q - factors [i] the resistance of the inductor [ii] the dynamic resistance of the circuit. [iii] The bandwidth of the circuit.	Sketch and explain the curve of impedance (Z) against frequency (f) for series circuit and parallel circuits. Define Q - factor (i.e. Q = Quality) for series connection and parallel connections and Calculate the resonant frequency and Q - factor of a series $L-C-R$ circuit. Lecture with examples	Inductor, capacitor, resistors, function generator, oscilloscope, multimeter/LCR meter, connecting wires, breadboard	Determine the behavior of a series LCR resonant circuit and to estimate the resonant frequency and Q-factor.	results. Direct the students to determine the behavior of a series LCR resonant circuit and to estimate the resonant frequency and	Ask the students to sketch the curve of impedance (Z) against frequency (f) for series circuit and parallel circuit. Ask students to define Q - factor (i.e. Q = Quality) for series connection and parallel connections and Calculate the resonant frequency and Q - factor of a series $L-C-R$ circuit.

General Objectives: 7.0 Translate the concept of three phase ac circuits.						
	7.1 Explain the meaning of a three - phase circuit. 7.2 Distinguish between three - phase, three-wire circuit and three phase, four-wire circuit. 7.3 Explain [i] line current [ii] line voltage. 7.4 Determine power in three-phase circuit. 7.5 Calculate the following parameters in a balanced three phase star-connected (Y) load, that is connected to a three-phase supply which has inductive reactance and resistance of known values for [i] impedance per phase [ii] the phase and line currents [iii] the total power consumed.	Explain the meaning of a three - phase circuit. Distinguish between three - phase, three-wire circuit and three phase. Calculate the following parameters in a balanced three phase star-connected (Y) load that is connected to a three-phase supply, which has inductive reactance and resistance of known values for impedance per phase, the phase and line and the total power consumed.	Three-phase dimmer stat, ammeter (ac), voltmeter (ac), multi-function meter, rheostats (3-number). Three-phase dimmer stat, ammeter (ac), voltmeter (ac), multi-function meter, rheostats (3-number).	To study the balanced three-phase system for star and delta connected load. To study the balanced three- phase system for star and delta connected three-phase load.	Direct the students to study the balanced three-phase system for star and delta connected load. Direct the students to study the balanced three-phase system for star and delta connected three-phase load.	Direct the student to explain the meaning of a three - phase circuit. Distinguish between three - phase, three-wire circuit and three phase. Direct the students to calculate the following parameters in a balanced three phase star-connected (Y) load that is connected to a three-phase supply, which has inductive reactance and resistance of known values for impedance per phase, the phase and line and the total power consumed.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title Electromagnetism 1	**Code:** PYE 314	**Contact Hours:** 4 Hours/Week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: The course is designed to acquaint students with the concept of static electricity and magnetic potential and their applications.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate the concept of static electricity and its applications
2.0 Outline the effects of induced charges in dielectrics
3.0 Apprehend the concept of magnetism
4.0 Appreciate magnetic fields and magnetic potential
5.0 Appreciate forces and torques in a magnetic field
6.0 Apprehend the concept of three phase ac circuits

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Electromagnetism I			**Code:** PYE 314		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 316		**Contact Hour:** 2 Hours/Week	
General Objective 1.0 Appreciate the concept of static electricity and its applications						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Electrostatics: 1.1 Explain the following [i] electrostatic fields [ii] Coulomb's Law [iii] electric Field intensity (EFI)	Explain electrostatic fields, Coulomb's Law and electric Field intensity (EFI)	Van de Graff Generator Gold Leaf Electroscope	Demonstrate the action of the Van de Graff generator.	Students should be involved in the demonstration of	Assigned students to explore behavior of electric charges using

	1.2 Explain electric field intensity EFI due to [i] a line and [ii] a surface charge 1.3 Describe work done in moving a point charge in an electrostatic field 1.4 Explain the term electric potential 1.5 State properties of [i] potential function [ii] potential gradient 1.6 State Gauss's law and explain application of Gauss's Law 1.7 State [i] Maxwell's first law, [ii] Laplace's and [iii] Poison's equations. 1.8 Explain [i] electric dipole [ii] dipole moment [iii] potential and [iv] electric field intensity EFI due to an electric dipole. 1.9 Derive an expression for the [i] potential, [ii] electric field, of an electric dipole	Explain the term electric potential Explain Gauss's law and explain application of Gauss's Law Explain Maxwell's first law, Laplace's, Poison's equations and electric dipole, dipole moment and potential. Derive an expression for the [i] potential, [ii] electric field, of an electric dipole	Lecture notes, reference texts and materials.		the Van de Graff generator.	combs, glass rods etc and draw conclusions. Give assignment involving the calculation of; electrostatic potential at a point, potential at different points and stating the relation between electric potential gradient and electric field and electric intensity EFI due to an electric dipole.
General Objectives 2.0 Outline the effects of induced charges in dielectrics						
	Dielectrics and Capacitance: 2.1 Describe the behavior of an electric field in [i]	Explain Conductors and Insulators, polarization of	Dielectric constant measurement trainer (Nvis 6111), solid	Determine the relative permittivity of dielectric medium	Direct the students to determine the relative	Give assignment for determining capacitances of

	Conductors and [ii] Insulators. 2.2 Explain the behavior of an Electric field inside a dielectric material. 2.3 Explain polarization of dielectric materials. 2.4 Define polarization vector and dipole moment. 2.5 State the relationship between polarization vector and dipole moment. 2.6 Define permittivity, relative permittivity (or dielectric constant), electric susceptibility. 2.7 State the dielectric boundary conditions. 2.8 Derive an expression for energy stored in dielectrics. 2.9 Define the capacitance of a capacitor. 2.10 Derive expressions for the capacitance of a [i] parallel plate [ii] cylindrical [iii] spherical capacitor. 2.11 Derive an expression for energy stored in a capacitor 2.12 Explain [i] current	dielectric materials Explain permittivity, relative permittivity (or dielectric constant electric susceptibility Explain capacitance of a capacitor. Explain current density, conduction and convection current densities Explain [i] current density [ii] conduction and [iii] convection current densities and state Ohm's	samples, mains cord, patch cord Lecture notes, reference texts and materials. -do-		permittivity of dielectric medium	capacitors with varying area, plate separation and dielectric constants. Assign numerical problems involving computation of polarization vector and dipole moment. Ask students to explain current density, conduction and convection current densities and state Ohm's law in point form and

	density [ii] conduction and [iii] convection current densities 2.13 State Ohm's law in point form and equation of continuity	law in point form and equation of continuity				equation of continuity
General Objectives 3.0 Apprehend the concept of magnetism						
	3.1. Explain static magnetic fields. 3.2. State Biot-Savart's law. 3.3. Define and explain magnetic field intensity (MFI). 3.4. Explain and derive expression for [i] magnetic field intensity due to a straight current carrying filament [ii] magnetic field intensity due to circular, square and [iii] magnetic field intensity solenoid current carrying wire 3.5. Derive expressions for the field current carrying conductor as in [i] infinite linear conductor [ii] circular loop [iii] the solenoid [iv] Toroid (Circular solenoid) 3.6. Explain magnetic flux and magnetic flux density (B)	Explain Biot-Savart's law and magnetic field intensity (MFI). Derive expression for magnetic field intensity Explain the derivation and expressions for the field current carrying conductor as in [i] infinite linear conductor [ii] circular loop [iii] the solenoid [iv] Toroid (Circular solenoid)	dc power supply, dynamometer, multimeter, 2 magnets. dc power supply, dynamometer, multimeter, 2 magnets.	Measure the force acting on a current- carrying conductor and observe the induction of electromotive force in a uniform magnetic field. Determine and verify the nature of the magnetic force acting on a current-carrying wire when the wire is placed in a magnetic field.	Direct the students to Measure the force acting on a current-carrying conductor and observe the induction of electromotive force in a uniform magnetic field. Direct students to predict and verify the nature of the magnetic force acting on a current-carrying wire when the wire is placed in a magnetic field.	Direct student to explain Biot-Savart's law, magnetic field intensity (MFI), Maxwell's second equation and Ampere's law Paramagnetic. Direct student to explain magnetic flux and magnetic flux density (B) and solve numerical problems

	3.7. Relate between magnetic flux and magnetic flux density 3.8. Write an expression for the force on a moving charge in a magnetic field density. 3.9. Derive [i] Maxwell's second equation, [ii] Ampere's Law and state their applications: 3.10. Ampere's circuital law and its applications viz. 3.11. Describe magnetic field intensity due to an infinite sheet of current and a long current carrying filament. 3.12. Derive the point form of Ampere's circuital law. 3.13. State Maxwell's third equation. 3.14. Explain ferromagnetic diamagnetic and paramagnetic. 3.15. List examples of ferromagnetic, diamagnetic and paramagnetic materials. 3.16. Explain the effects of strong non-uniform field on these materials.	Explain the derivation of [i] Maxwell's second equation, [ii] Ampere's law and state their applications. Describe magnetic field intensity due to an infinite sheet of current and a long current carrying filament and derive the point form of Ampere's circuital law. Explain	Deflection magnetometer, circular coil, dc power supply, measuring scale. Lecture notes, reference texts and materials.	Measurement of the magnetic field along the axis of a current carrying circular coil to verify Biot Savart law and to estimate the radius of the coil.	Direct the students to measure the magnetic field along the axis of a current carrying circular coil to verify Biot Savart law and to estimate the radius of the coil.	Direct the students to explain the derivation of Maxwell's second equation, and Ampere's law, stating their applications. Instruct the students to describe magnetic field intensity due to an infinite sheet of current and a long current carrying filament and derive the point form of Ampere's circuital law. Ask the students to explain

	3.17. Describe how atoms of a diamagnetic material acquire induced magnetic dipole moments in direction opposite to an applied magnetic field. 3.18. Define the magnetization vector m of a magnetic material. 3.19. Explain qualitatively domains and curve point. 3.20. Interpret the equation $B = B_o + B_m$ for various magnetic materials.	ferromagnetic diamagnetic and paramagnetic materials. List examples of ferromagnetic, diamagnetic and paramagnetic materials. Define the magnetization vector m of a magnetic material, explain qualitatively domains, and curve point. Interpret the equation $B = B_o + B_m$ for various magnetic materials.	-do-			ferromagnetic diamagnetic and paramagnetic behavior. List examples of ferromagnetic, diamagnetic and paramagnetic materials. Direct the students to define the magnetization vector m of a magnetic material, explain qualitatively domains, and curve point. Interpret the equation $B = B_o + B_m$ for various magnetic materials.
General Objectives 4.0 Appreciate magnetic fields and magnetic potential						
	4.1 Explain magnetic force on moving charges in a Magnetic field. 4.2 Write an expression for the Lorentz force experienced by [i] a	Explain magnetic force on moving charges in a Magnetic field Explain	Equipment set electromagnetism, permanent magnet with adjustable pole spacing, 1 dc	Determine the direction of the Lorentz force. - Measure the force as a function	Direct the students to determine the direction of the Lorentz force.	Explain magnetic force on moving charges in a Magnetic field

	current element in a magnetic field [ii] a straight and a long current carrying conductor in a magnetic field [iii] Force between two straight long and parallel current carrying conductors 4.3 Derive an expression for magnetic field of a magnetic dipole. 4.4 Explain the term [i] magnetic dipole and [ii] dipole moment. 4.5 Describe a differential current loop as a magnetic dipole. 4.6 Explain magnetic potential and its limitations. 4.7 Explain vector magnetic potential and its properties. 4.8 State Gauss Law of magnetism 4.9 Define Inductance of an inductor. 4.10Derive an expression for the inductance of an inductor 4.11Derive an expression for the energy stored in	differential current loop as a magnetic dipole and its limitations and Gauss Law of magnetism Explain Neumann's formulae and Stokes' theorem Describe a differential current loop as a magnetic dipole and explain magnetic potential and its limitations Derive an expression for the inductance of an	power supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz) or dc power supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz), Pair of safety experimental Leads, 75cm, red/blue. Lecture notes, reference texts and materials.	of the current. - Measure the force as a function of the effective length of the conductor. - Measure the force as a function of the distance between the pole shoes of the permanent magnet.	- Measure the force as a function of the current. - Measure the force as a function of the distance between the pole shoes of the permanent magnet.	Explain differential current loop as a magnetic dipole and its limitations and Gauss Law of magnetism Explain Neumann's formulae and Stokes' theorem Ask students to describe a differential current loop as a magnetic dipole and explain magnetic potential and its limitations. Instruct the students to derive an expression for the inductance

	an inductor. 4.12 Explain self and mutual inductance. 4.13 Explain Neumann's formulae. 4.14 Explain the determination of [i] self-inductance of a solenoid [ii] toroid and [iii] mutual inductance between a straight long wire and a square loop wire in the same plane. 4.15 Explain energy stored and energy density in a magnetic field. 4.16 Define the curl of a vector. 4.17 Explain magnetic vector potential. 4.18 State Stokes' theorem	inductor and for the energy stored in an inductor. Explain the determination of [i] self-inductance of a solenoid [ii] toroid and [iii] mutual inductance between a straight long wire and a square loop wire in the same plane	-do-			of an inductor and for the energy stored in an inductor. Solve numerical problems. Ask the students to explain the determination of self-inductance of a solenoid, toroid and mutual inductance between a straight long wire and a square loop wire in the same plane
General Objectives 5.0 Appreciate forces and torques in a magnetic field						
	5.1 Describe magnetic forces on particles. 5.2 Explain the combined effects of electrical and magnetic fields. 5.3 Explain magnet force on a current element. 5.4 Derive expressions for the force and torque on coils. 5.5 Calculate the force on a current carrying	Explain magnetic forces on particles, magnetic force on a current element and magnetic moment of a planar coil	Constant current Power supply DC 0-16 V, 5 Amp, Digital Gauss meter with Axial Hall Probe (Transducer), current carrying coil with 390 turns (N), 1 diameter 150 mm, 1 support base and stand, 1	Determine the magnetic field variation along the axis of a circular coil and a Helmholtz coil.	Direct the students to determine the magnetic field variation along the axis of a circular coil and a Helmholtz coil	Ask the students to explain magnetic forces on particles, magnetic force on a current element and magnetic moment of a planar coil

	conductor 5.6 Explain magnetic moment of a planar coil		deflection compass, 1 multimeter, onnecting leads			
General Objectives 6.0 Apprehend the concept of three-phase ac circuits						
	6.1 Estimate the field in a long cylindrical solenoid having n turns per unit length of thin wire carrying current I. 6.2 Derive the total field inside the solenoid as $B = \mu_o (H + M)$ where μ_o = permeability of free space and M is magnetization vector. 6.3 Explain magnetic susceptibility and permeability of various materials. 6.4 Interpret the relation $B = \mu_o (H + M)$ for magnets. 6.5 List the materials used in making magnets (permanent and temporary). 6.6 Derive the magnetic field inside a toroid. 6.7 Calculate the field in the gap of a particular electromagnet. 6.8 State the relationship	Take students through the derivation of a field in a long cylindrical solenoid having n turns per unit length of thin wire carrying current ***I***. Explain magnetic susceptibility and permeability of various materials in the derivation above. Explain the materials that can be used in making magnets (permanent and temporary).	1 large solenoid of about 500-600 turns (of 20 s.w.g enameled copper wire) and of diameter c. 5cm, 2 ammeter (5 amp), 2 accumulator (or bench) source of supply, 2 controlled rheostat, 2 depression key K, 2 search coil of expt. 96, plug-in resistance box, ballistic galvanometer with lamp and scale stand to support search coil,2 meter rule 1 deflection	Determine the magnetic field variation along the axis of a solenoid. Measure the magnetic field	Direct the students to determine the magnetic field variation along the axis of a solenoid Direct the students to	Direct the students to explain magnetic susceptibility and permeability of various materials in the derivation above. Direct the students to explain the materials that can be used in making magnets (permanent and temporary).

	between B and H. 6.9 Draw the $B-H$ curve for (i) soft iron (ii) hard steel. 6.10 Explain the making of permanent magnets. 6.11 Calculate the total flux from a pole of a magnet given the flux density and the dimensions of the magnet's pole surface.	State the relationship between B and H and draw the $B-H$ curve for (i) soft iron (ii) hard steel.	magnetometer, 1 circular coil, 1 dc power supply, and measuring scale	along the axis of a current carrying circular coil to verify Bio-Savart's Law and estimate the radius of the coil.	Measure the magnetic field along the axis of a current carrying circular coil to verify Bio-Savart's Law and to estimate the radius of the coil.	Instruct the students to state the relationship between B and H and draw the $B-H$ curve for (i) soft iron (ii) hard steel.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title Introduction to Solid State Physics	**Code:** PYE 315	**Contact Hours:** 2 Hours/Week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** First	**Practical:** 0 Hours/week

Course main Goal: **The course is designed to acquaint students with the fundamental concepts of solid-state physics and its applications.**

General Objectives:

On the completion of the course, the student should be able to:

1.0 Comprehend crystals, lattices, and symmetry
2.0 Comprehend crystal diffraction and reciprocal lattice
3.0 Comprehend free electron theory of solids
4.0 Comprehend band theory of solids and semiconductors
5.0 Comprehend the concepts of dielectrics and its related properties
6.0 Comprehend superconductors: theory and devices

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Introduction to Solid State Physics			**Code:** PYE 315		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** None		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Comprehend **crystals, lattices, and symmetry**						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Distinguish between crystalline and amorphous solid 1.2 Explain the following [i] crystal and [ii] crystal lattice. 1.3 Explain lattice points and space points 1.4 Explain the following [i] basis and crystal structure [ii] unit cell and primitive cell 1.5 Explain crystal systems and crystal symmetry (symmetry elements in crystals). 1.6 Explain the Bravais Lattices. 1.7 Explain the following [i] simple cubic crystal system, [ii] fcc crystal system, [iii] body-centered cubic [iv] three dimensional lattice Types 1.8 Explain crystal symmetry and symmetry operations (translational symmetry, rotational system, reflection and inversion) 1.9 Explain crystal direction and place	Lecture with examples Distinguish between crystalline and amorphous solid, and explain [i] crystal and [ii] crystal lattice. Explain crystal symmetry and symmetry operations (translational symmetry, rotational system, reflection and inversion)	Lecture notes and reference texts. -do-			Ask students to distinguish between crystalline and amorphous solid, and explain [i] crystal and [ii] crystal lattice. Ask students to explain crystal symmetry and symmetry operations (translational symmetry, rotational system, reflection and

	1.10 Explain Miller Indices 1.11 Describe inter planer spacing 1.12 State the important features of Miller indices of crystal planes. 1.13 Obtain the relation between the density of crystal material and the lattice constant in a cubic lattice. 1.14 Explain some important crystal structure (Sodium Chloride (NaCl), Cesium Chloride (CeCl)), Hexagonal Close Packed (hcp), Diamond, Zinc Sulfide (ZnS), Perovskite etc). 1.15 Explain the Wigner Seitz cell. 1.16 Explain quasi and liquid crystals. 1.17 Describe allotropy and polymorphism 1.18 Explain imperfections in crystals (thermal vibrations, point defects, vacancies, interstitials, Schottky defects and Frenkel defects, compositional defects, electronics defects). 1.19 Explian [i] line imperfections, [ii] screw dislocation surface imperfections, [ii] Burger's vector 1.20 Explain [i] external surface imperfection and [ii] internal surface imperfections (grain boundaries, tilt boundaries, twin boundaries). 1.21 Explain [i] stacking defect and [ii] volume defect.	Describe inter planer spacing State the important features of Miller indices of crystal planes. Obtain the relation between the density of crystal material and the lattice constant in a cubic lattice Explain imperfections in crystals (thermal vibrations, point defects, vacancies, interstitials, Schottky defects and Frenkel defects, compositional defects, electronics defects).	Lecture notes and reference texts. -do-			inversion) Direct students to state the important features of Miller indices of crystal planes and obtain the relation between the density of crystal material and the lattice constant in a cubic lattice Direct students to explain imperfections in crystals (thermal vibrations, point defects, vacancies, interstitials, Schottky defects and Frenkel defects, compositional defects, electronics defects).

General Objectives 2.0 Comprehend crystal diffraction and reciprocal lattice						
	2.1 Explain X-ray diffraction 2.2 Explain diffraction of waves by crystal lattice. 2.3 Explain [i] Laue's concept of X-ray diffraction and [ii] Bragg's concept of X-ray diffraction. 2.4 State Bragg's law and prove the Bragg's law. 2.5 State Bragg's law in reciprocal space. 2.6 Explain Bragg's X-ray spectrometer 2.7 Explain the various diffraction methods [i] Laue method, [ii] rotating crystal method and [iii] powder method 2.8 Explain neutron diffraction and electron diffraction techniques for studying crystal structure. 2.9 Explain [i] reciprocal lattice [ii] reciprocal lattice vectors [iii] Reciprocal lattice of bc, sc and fcc. 2.10 Explain diffraction condition in reciprocal lattice 2.11 Explain neutron diffraction and electron diffraction techniques for studying crystal structure. 2.12 Explain concept of reciprocal lattice 2.13 Explain reciprocal lattice of monoclinic crystal 2.14 Construction of reciprocal lattice	Lecture with examples Explain X-ray diffraction and diffraction of waves by crystal lattice Explain [i] Laue's concept of X-ray diffraction and [ii] Bragg's concept of X-ray diffraction. State Bragg's law and prove the Bragg's law. State Bragg's law in reciprocal space and explain Bragg's X-ray spectrometer. Solve numerical problems using the expressions stated	Lecture notes and reference texts. -do-			Ask students to explain X-ray diffraction and diffraction of waves by crystal lattice Direct students to explain [i] Laue's concept of X-ray diffraction [ii] Bragg's concept of X-ray diffraction [iii] state and prove the Bragg's law, [iv] state Bragg's law in reciprocal space and explain Bragg's X-ray spectrometer. Obtain reciprocal lattice of simple

	of monoclinic crystal. 2.15 Explain reciprocal lattice vectors: 2.16 Obtain reciprocal lattice of simple cubic crystal and reciprocal lattice to fcc crystal. 2.17 Explain the diffraction condition in reciprocal lattice system. 2.18 Explain the properties of reciprocal lattice. 2.19 Explain the concept of a Brillouin zones 2.20 Explain Brillouin zones in two dimensions.	Obtain reciprocal lattice of simple cubic crystal and reciprocal lattice to fcc crystal. Explain the diffraction condition in reciprocal lattice system and explain the properties of reciprocal lattice.	-do-			cubic crystal and reciprocal lattice to fcc crystal. Explain the diffraction condition in reciprocal lattice system and explain the properties of reciprocal lattice.
General Objective 3.0 Comprehend **free electron theory of solids**						
	3.1 Explain the classical free electron theory of metals 3.2 Explain the classical theory of electric conduction 3.3 Explain the temperature dependence of electrical resistivity 3.4 Explain the drawbacks of classical theory [i] heat capacity of electron gas, [ii] computation of mean free path and [iii] relation between electrical conductivity and thermal conductivity (Wiedemann-Franz law) 3.5 Explain relaxation time, collision time and mean free path. 3.6 Explain Fermi energy 3.7 Explain Fermi-Dirac statistics	Lecture with examples Explain the classical free electron theory of metals and classical theory of electric conduction Explain the temperature dependence of electrical resistivity Explain the drawbacks of classical theory [i] heat capacity of	Lecture notes and reference texts.			Ask students to explain the classical free electron theory of metals and classical theory of electric conduction. Direct the students to explain the temperature dependence of electrical resistivity Direct the students to explain the drawbacks of

	and electronic distribution in solids 3.8 Obtain the density of energy state and Fermi energy 3.9 Explain the Fermi distribution function. 3.10 Obtain the heat capacity of free electron gas. 3.11 Obtain the expression for the mean of electron gas at absolute zero. 3.12 Explain the effect of temperature on Fermi distribution function.	electron gas, [ii] computation of mean free path and [iii] relation between electrical conductivity and thermal conductivity (Wiedemann-Franz law)	-do-			classical theory [i] heat capacity of electron gas, [ii] computation of mean free path and [iii] relation between electrical conductivity and thermal conductivity (Wiedemann-Franz law)
General Objectives 4.0 Comprehend band theory of solids and semiconductors						
	4.1 Explain the band structure of semiconductors 4.2 Explain semiconductors 4.3 Explain intrinsic semiconductors. 4.4 Explain the effect of temperature on the conductivity of a semiconductor. 4.5 Explain the statistics of electrons and holes in intrinsic semiconductors. 4.6 Explain the effect of electrical conductivity to an intrinsic semiconductor. 4.7 Explain semiconductors or extrinsic semiconductors. 4.8 Explain the statistics of extrinsic semiconductors. 4.9 Obtain a general equation for an impurity semiconductor. 4.10 Derive the Fermi level in impurity	Lecture with examples Explain semiconductors and the band structure of semiconductor. Explain the statistics of extrinsic semiconductor sand derive the Fermi level in impurity	Lecture notes and reference texts. -do-			Direct student to explain semiconductors and the band structure of semiconductor. Ask students to explain the statistics of extrinsic semiconductor sand derive the

	semiconductors. 4.11 Derive the general equation for an impurity semiconductor. 4.12 Explain the Fermi level in an n-type semiconductor at very low temperature. 4.13 Derive the theory of [i] n-type semiconductors and [ii] p-type semiconductors. 4.14 Explain the variation of carrier concentration with temperature. 4.15 Explain conductivity in extrinsic semiconductors. 4.16 Explain the mechanism of current conduction in semiconductors: [i] current flow in a biased n-type semiconductor and [ii] current flow in a biased p-type semiconductor. 4.17 Explain generation and recombination in semiconductors. 4.18 Explain minority carrier lifetime 4.19 Explain mobility of current carriers in semiconductors. 4.20 Explain drift and diffusion 4.21 Explain and derive Einstein relation i.e. relation between diffusion coefficient and mobility of a charge carrier. 4.22 General study of excess carrier movement: [i] the continuity equation [ii] net recombination rate [iii] rate of increase due to drift [iv] rate of increase due to	semiconductors. Explain the mechanism of current conduction in semiconductors: [i] current flow in a biased n-type semiconductor and [ii] current flow in a biased p-type semiconductor.	Lecture notes and reference texts. -do-			Fermi level in impurity semiconductors. Direct students to explain the mechanism of current conduction in semiconductors: [i] current flow in a biased n-type semiconductor and [ii] current flow in a biased p-type semiconductor.

	diffusion and [v] diffusion length. 4.23 Explain Hall effect and determine the Hall coefficient. 4.24 Describe the application of Hall effect. 4.25 State the advantages of semiconductor devices. 4.26 Explain p-n junction and the potential barrier at a p-n junction. 4.27 Explain width of depletion layer of the p-n junction. 4.28 Explain volt-Ampere characteristics of the p-n junction. 4.29 Explain the application of voltage across a p-n junction [i] forward biasing [ii] reverse biasing. 4.30 Explain V-I characteristics of a p-n junction. 4.31 Derive [i] rectifier equation and [ii] continuity equation 4.32 Explain the various types of diode and their applications: [i] Zener diode [ii] varactor diode [iii]breakdown diode [iv] tunnel diode [v] photo diode, [vi] light emitting diodes	Explain Hall effect, determine the Hall coefficient and describe the application of Hall effect. Explain p-n junction and the potential barrier at a p-n junction. Explain width of depletion layer of the p-n junction and volt-Ampere characteristics of the p-n junction	Lecture notes and reference texts.			Ask students to Explain Hall effect, determine the Hall coefficient and describe the application of Hall effect. Direct students to explain p-n junction and the potential barrier at a p-n junction. Direct explain width of depletion layer of the p-n junction and volt-Ampere characteristics of the p-n junction
General Objectives 5.0 Comprehend the concepts of dielectrics and its related properties						
	5.1 Explain the concept of dielectrics. 5.2 Explain dielectric constant and susceptibility. 5.3 Derive Gauss law in the presence	Lecture with examples Explain the concept of dielectrics, dielectric constant and	Lecture notes Reference texts			Ask students to Explain the concept of dielectrics, dielectric constant

	of the dielectric. 5.4 Explain dipole moment and polarization. 5.5 Explain the microscopic concept of polarization (i.e. dielectric polarization. 5.6 Explain the following [i] dispersion of dielectric polarization [ii] electronic polarization [iii] ionic polarization [iv] orientation polarization and [v] space charge polarization. 5.7 State Lan gevin theory of polarization in polar dielectrics. 5.8 Explain molecular theory of induced charges in a dielectric 5.9 Explain capacitance of a parallel plate capacitor and derive Lorentz field. 5.10 Derive the equation for field of dipoles inside Cavity. 5.11 Explain the molecular description of polarization 5.12 Determine the Clausius – mossotti relation. 5.13 Determine the relation between dielectric constant and refractive index (Lorentz-Lorenz formula). 5.14 Explain the following [i] ferro electricity and [ii] anti-ferro electricity. 5.15 Explain piezoelectricity 5.16 Explain dielectrics in alternating	susceptibility. Explain the following [i] dispersion of dielectric polarization [ii] electronic polarization [iii] ionic polarization [iv] orientation polarization and [v] space charge polarization. Explain molecular theory of induced charges in a dielectric Explain capacitance of a parallel plate capacitor and derive Lorentz field and derive the equation for field of dipoles inside Cavity. Explain capacitance of a parallel plate capacitor and derive Lorentz field and	-do-			and susceptibility. Direct students to explain the following [i] dispersion of dielectric polarization [ii] electronic polarization [iii] ionic polarization [iv] orientation polarization and [v] space charge polarization. Direct students to explain capacitance of a parallel plate capacitor and derive Lorentz field and derive the equation for field of dipoles inside Cavity.

	fields and describe the properties of dielectrics in alternating fields. 5.17 Explain the complex dielectric constant and dielectric loss. 5.18 Explain ionic polarization as a function of frequency. 5.19 Obtain the complex dielectric constant of nonpolar solids. 5.20 Explain dipolar relaxation. 5.21 Explain the dipole theory of ferro electricity. 5.22 Describe the classification of ferroelectric materials 5.23 Explain absorption of energy and dielectric losses. 5.24 Describe the effects of dielectrics [i] dielectric relaxation [ii] dielectric absorption and [iii] dielectric breakdown [iv] intrinsic breakdown [v] thermal breakdown [vi] discharge breakdown and [vii] electrochemical breakdown. 5.25 Explain dielectric losses and dielectric loss angle. 5.26 Explain total and specific dielectric losses. 5.27 Explain the important requirements of good insulating materials and list some important insulating materials.	derive the equation for field of dipoles inside Cavity. Explain the effects of dielectrics [i] dielectric relaxation [ii] dielectric absorption and [iii] dielectric breakdown [iv] intrinsic breakdown [v] thermal breakdown [vi] discharge breakdown and [vii] electrochemical breakdown.	Lecture notes and reference texts			Direct students to explain the effects of dielectrics [i] dielectric relaxation [ii] dielectric absorption and [iii] dielectric breakdown [iv] intrinsic breakdown [v] thermal breakdown [vi] discharge breakdown and [vii] electrochemical breakdown.

General Objectives: 6.0 Comprehend superconductors: theory and devices						
	6.1 Describe the concept of superconductivity. 6.2 Explain the classification of superconductors 6.3 State the basic properties of superconductors. 6.4 List some applications of superconductivity. 6.5 Explain the effect of Joule heating on superconductor. 6.6 Give account of the mechanism of superconductors. 6.7 Describe the effect of [i] magnetic field [ii] ac resistivity and [iii] critical current on superconductors. 6.8 Explain flux exclusion: the Meissner effect 6.9 Explain thermal properties effects on superconductors [i] entropy, [ii] specific heat, [iii] thermal conductivity, and [v] acoustic attenuation. 6.10 Describe energy gap in superconductors. 6.11 Explain [i] isotope and [ii] mechanical effects as related to superconductors. 6.12 Explain the concept of London theory and derive the first and second London equations. 6.13 Explain London penetration depth.	Lecture with examples Explain the concept of superconductivity and state the basic properties of superconductors. Give account of the mechanism of superconductors and explain the effect of [i] magnetic field [ii] ac resistivity [iii] critical current on superconductors and explain flux exclusion: the Meissner effect Explain the concept of London theory, derive the first London equation, second London equations, and	Lecture notes Reference texts -do-			Ask the students to explain the concept of superconductivity and state the basic properties of superconductors. Direct students to give account of the mechanism of superconductors and explain the effect of [i] magnetic field [ii] ac resistivity [iii] critical current on superconductors and explain flux exclusion: the Meissner effect Direct students to explain the concept of London theory, derive the first London equation, second London equations, and explain London

	6.14 Explain temperature dependence of the London penetration depth. 6.15 Describe the behavior of superconductors in ac fields 6.16 Explain the thermodynamics of superconductors. 6.17 Describe the concept of Bardeen-Cooper Schrieffer (BSC) theory. 6.18 Explain [i] coherence length [ii] BSC ground state and [iii] the BSC theory in a capsule. 6.19 Explain the theory of Josephson effect. 6.20 Explain ac Josephson effect	explain London penetration depth. Explain temperature dependence of the London penetration depth. Explain the concept of Bardeen-Cooper Schrieffer (BSC) theory and explain [i] coherence length [ii] BSC ground state and [iii] the BSC theory in a capsule.	-do-			penetration depth. Ask students to explain the concept of Bardeen-Cooper Schrieffer (BSC) theory and explain [i] coherence length [ii] BSC ground state and [iii] the BSC theory in a capsule.

HND I SEMESTER 2

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Thermodynamics	**Code: PY**E 321	**Contact Hours:** 4 Hours/Week
Credit Units: 2 Units	**Pre-requisite:**	**Theoretical**: 2 Hours/week
Year : 1	**Semester: Second**	**Practical**: 2 Hours/week

Course main Goal: The course is designed to acquaint students with the concept of the laws of thermodynamics and its applications

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apprehend the first law of thermodynamics
2.0 Apprehend the second law of thermodynamics
3.0 Outline the processes by which changes in thermodynamics system are affected
4.0 Apprehend the first Properties law of thermodynamics of pure substances
5.0 Apprehend the third law of thermodynamics

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Thermodynamics			**Code:** PYE 321		**Credit Units: 2 Units**	
Course specifications: Theoretical contents			**Practical Code:** PYE 327		**Contact Hours:** 2 Hours/Week	
General Objectives: 1.0 Apprehend the first law of thermodynamics						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Basic Concepts of Thermodynamics 1.1 Explain the terms: [i] state [ii] equilibrium [iii] processes [iv] cycles.	Lecture and give numerical examples and assignments	Lecture notes and reference texts.			Teacher assesses/rates students' understanding of first law from

	1.2 State temperature and the Zeroth law of thermodynamics 1.3 Write the ideal-gas equation of state. 1.4 Define specific heat capacity. 1.5 Explain the concept of work done by an expanding gas. 1.6 Interpret the ratio of specific heat capacities, i.e. $C_p/C_v = \hat{W}$ where C_p , C_v are specific heat capacities at constant pressure and volume respectively, $\hat{W}$ is a constant. 1.7 State the first law of thermodynamics. 1.8 Prove that $C_p - C_v = R$ where R is gas constant. 1.9 Calculate the values of $\hat{W} = C_p/C_v$ for a gaseous mixture. The gases are assumed to be ideal. C_p, is specific heat capacity at constant pressure, C_v is specific heat capacity at constant volume.	Explain the terms: [i] state [ii] equilibrium [iii] processes [iv] cycles. State and derive temperature and the Zeroth law of thermodynamics Prove that $C_p - C_v = R$ where R is gas constant and calculate the values of $\hat{W} = C_p/C_v$ for a gaseous mixture. The gases are assumed to be ideal. C_p, is specific heat capacity at constant pressure, C_v is specific heat capacity at constant volume.	-do-			explanation of terms. Rate students' understanding of specific heat capacity, the concept of work done by an expanding gas and Interpret the ratio of specific heat capacities by quiz questions. Direct the students to state the first law of thermodynamics, prove that $C_p - C_v = R$ and Calculate the values of $\hat{W} = C_p/C_v$ for a gaseous mixture.
General Objectives 2.0 Apprehend the second law of thermodynamics						
	Second Law of Thermodynamics 2.1 Explain heat engines, refrigerators, and heat	Lecture with the help of sketch graph	Lecture notes and texts.			Students should be guided to establish the equivalence of different statements

	pump. 2.2 Describe thermal-energy reservoirs. 2.3 State the second law of thermodynamics. 2.4 State the Kelvin-Planck statement of the second law thermodynamics. 2.5 Explain Carnot cycle 2.6 Explain the second law using working cycles on the P-V diagram for heat engines and refrigerators. 2.7 Derive expressions for [i] work done in a Carnot engine; [ii] efficiency of the Carnot engine. 2.8 State the Clausius statement of the second law thermodynamics. 2.9 Explain the Equivalence of the Kelvin-Planck and Clausius statements. 2.10 Explain the equivalence of the ideal gas temperature and Kelvin temperature. 2.11 Describe reversible and irreversible process. 2.12 Explain why a reversible process is impossible in reality. 2.13 Explain General second law limitations for heat engines, refrigerators, and	Lecture State the Clausius statement of the second law thermodynamics and explain the Equivalence of the Kelvin-Planck and Clausius statements. Explain the concept of entropy and the entropy change of pure substances. Lecture with examples	-do- Lecture notes and texts.			of Second Law. Direct the students to explain Carnot cycle and Second Law of thermodynamics using working cycles on the P-V diagram for heat engines and refrigerators. Students are guided by teacher to verbally distinguish between reversible and irreversible processes.

	heat pumps. 2.14 Explain the concept of entropy. 2.15 Explain the increase of entropy principles. 2.16 Describe the entropy change of pure substances. 2.17 Explain isentropic processes. 2.18 Explain entropy change of [i] solids [ii] liquids [iii] ideal gases. 2.19 Explain the second law in terms of entropy change for heat engines and refrigerators. 2.20 State the Tds equations. 2.21 Describe the Joule-kelvin effect. 2.22 Obtain conditions for Joule-kelvin effect, using the Tds equation and inversion curves. 2.23 Describe the process of liquefaction of gas, using Joule- Kelvin effect.	State the Tds equations. Describe the Joule-kelvin effect and obtain conditions for Joule-kelvin effect, using the Tds equation and inversion curves.	-do- Lecture notes and texts.			Students are guided to explain the concept of entropy and establish the equivalence of different statements of Second Law. Students are to be given some exercises on the second law in terms of entropy change for heat engines and refrigerators as tutorial to enhance better understanding. Ask students to state the Tds equations. Describe the Joule-kelvin effect and obtain conditions for Joule-kelvin effect, using the Tds equation and inversion curves
General Objectives 3.0 Outline the Processes by which changes in thermodynamics system are affected						
	3.1 State how processes affect changes in a thermodynamic system.	Lecture with the help of sketch graph	Lecture notes and texts.			Ask the student to distinguish between flow and non-flow

	3.2 Distinguish between flow and non-flow processes. 3.3 State the condition that must be satisfied by steady flow processes. 3.4 Derive the steady flow energy equation (SFEE) $Q = W = m(h_2 - h_1) + \frac{m}{2000}({c_2}^2 - {c_1}^2) + \frac{mg}{1000}(z_2 - z_1)$ where $h =$ specific enthalpy; $m =$ mass flow rate into the control volume; $c =$ velocity; z = height above a datam level; g = acceleration due to gravity; Q = heat transfer rate; $W =$ Rate at which work is done. 3.5 Apply the steady – flow energy equation to boiler, condensers, turbines and compressors. 3.6 Derive the non-flow energy equation $U_2 - U_1 = Q$ Where U_2 is the final energy of a system; U_1 is the initial energy of the system; Q is the quantity of heat transferred and W is the work done. 3.7 Apply the non-flow	Distinguish between flow and non-flow processes and State the condition that must be satisfied by steady flow processes. Lecture with examples	-do- Lecture notes and texts.			processes. Rate students' understanding of steady flow energy, by quiz questions and apply the steady – flow energy equation to boiler, condensers, turbines and compressors. Direct the students to apply the non-flow equation to constant volume processes; constant pressure processes; adiabatic processes; and polytropic processes.

	equation to: [i] constant volume processes; [ii] constant pressure processes; [iii] adiabatic processes; and [iv] polytropic processes.					
General Objectives 4.0 Apprehend to the first properties law of thermodynamics of pure substances						
	4.1 Define internal energy, U. 4.2 Define enthalpy, $H = U + PV$ 4.3 Explain internal energy, enthalpy, and specific heats of ideal gases 4.4 Explain internal energy, enthalpy, and specific heats of solids and liquids. 4.5 Describe how the change in enthalpy for an isobaric process is equal to the heat transferred. 4.6 Apply enthalpy to: [i] throttling process; and [ii] a pure substance undergoing a reversible process. 4.7 Define the Helmholtz function, $F = U - T_s$. 4.8 Explain how the changes of Helmholtz function during an isothermal process equal the work done on the system. 4.9 Define the Gibbs's function, $G = U - T_s + PV$. 4.10 Derive the Maxwell's	Define internal energy, U enthalpy, $H = U + PV$ and explain internal energy, enthalpy, and specific heats of ideal gases Explain how the changes of Helmholtz function during an isothermal process equal the work done on the system. Define the Gibbs's function, $G = U - T_s +$	Lecture notes and texts. -do-			Students are to be given some exercises on internal energy, enthalpy and specific heat of ideal gases tutorial to enhance better understanding. Ask the how the changes of Helmholtz function during an isothermal process equal the work done on the system. Direct students to define the Gibbs's

	equations on the Tds equations by applying the thermodynamic potentials. 4.11 Determine the principal specific heat capacities using Maxwell's equation.	PV and derive the Maxwell's equations on the Tds equations by applying the thermodynamic potentials.				function, $G = U - T_s + PV$ and derive the Maxwell's equations on the Tds equations by applying the thermodynamic potentials. Solve numerical problems.
General Objectives 5.0 Apprehend the third law of thermodynamics						
	Third Law of Thermodynamics 5.1 State the third law of thermodynamics. 5.2 List the elementary physical consequences of the third law. 5.3 Explain the unattainability of absolute zero Derive. 5.4 Describe the mathematical explanation of the third law. 5.5 Describe the applications of the third law of thermodynamics. 5.5 Apply the third law to allotropic transformation and glasses.	Lecture with examples State the Third law of thermodynamics and list the elementary physical consequences of the third law.				Direct the students to explain Carnot cycle and Third law of thermodynamics and state elementary physical consequences of the third law. Solve numerical problems

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Electromagnetism II	**Code:** PYE 322	**Contact Hours:** 4Hours/week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** Second	**Practical:** 2 Hours/week

Course main Goal: The course is designed to acquaint students with the concept of the principles of electromagnetic waves and their propagation in free space and matter

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apply Principle of electromagnetic induction
2.0 Apply Maxwell's equations and their solutions
3.0 Outline the properties of electromagnetic waves and their propagation in free space and matter
4.0 Outline the propagation of high frequency signals along transmission lines
5.0 Outline the propagation of high frequency signal wave - guides

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Electromagnetism II			**Code:** PYE 322		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 327		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Apply principle of electromagnetic induction						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Electromagnetic induction 1.1 State Faraday's law of electromagnetic induction 1.2 State Lenz's law of electromagnetic induction	Discuss the following laws of electromagnetic induction: (i) Faraday's law	Oscillator, function generator, 5 neodymium magnets, solenoid, Vernier Magnetic Field	Use Faraday's Law to determine the magnetic field of a magnet	The students should use Faraday's Law to determine the	Direct the students to state and derive the following electromagnetic

	1.3 Express Faraday's law and Lenz's law of electromagnetic induction mathematically 1.4 Explain induced e.m.f. and induced current. 1.5 Derive an expression for induced e.m.f. in [i] a rod moving in a magnetic field, [ii] A rectangular coil [iii] circular coil, moving in a magnetic field. 1.6 Explain practical applications of electromagnetic induction in general of electrical power, and in betatron. 1.7 Deduce the differential form of Faraday's Law from the integral form. 1.8 Explain self-inductance and mutual inductance. 1.9 Derive expressions for self-inductance and mutual inductance of circuits. 1.10 Derive an expression for the energy stored in an inductor. 1.11 and total magnetic energy of a system of currents. 1.12 Explain hysteresis losses in ferromagnetic materials 1.13 Draw the hysteresis loop for soft and hard magnetic	(ii) Lenz laws Express the laws above mathematically. Explain induced e.m.f. and induced current. Show how to derive an expression for induced e.m.f. in [i] a rod moving in a magnetic field, [ii] A rectangular coil [iii] circular coil, moving in a magnetic field. Discuss practical applications of electromagnetic induction in general of electrical power, and in betatron. Explain how to deduce the differential form of Faraday's Law from the integral form. Explain self-	Sensor, Vernier Current probe, Vernier computer interface, Vernier computer software and multimeter. Function Generator, Oscilloscope, One large and two small (with handles) coils, plastic triangles, T-base, BNC connector and graph paper. Sensor-CASSY (1), U-core with yoke (1), Coils (N = 500 turnes, L = 2.2 mH) (2), Clamping device, Function generator S12 (1), 12 V DC power supplies (2), STE resistor 1Ω, 2W (1), Socket board section (1), Connecting lead, 50 cm (1), Connecting leads, 100 cm (7), PC with Windows 98 and CASSY Lab software	Demonstrate the Faraday's Law of electromagnetic induction. Determine the properties of magnetic materials and hysteresis loop measurements	magnetic field of a magnet. Demonstrate the Faraday's Law of electromagnetic induction. Ask the students to Determine the properties of magnetic materials and hysteresis loop measurements	laws: Faraday's law and Lenz laws Direct the students to explain induced e.m.f., induced current and derive an expression for induced e.m.f. in a rod moving in a magnetic field, a rectangular coil and circular coil, moving in a magnetic field. Solve numerical problems. Ask the students to deduce the differential form of Faraday's Law from the integral form and derive expressions for self-inductance

	materials. 1.14 Explain energy product, and maximum energy product. 1.15 Solve numerical problems.	inductance and mutual inductance and drive expressions on them. Show how to derive; an expression for the energy stored in an inductor and total magnetic energy of a system of currents. Discuss the hysteresis loses in ferromagnetic materials and illustrate the hysteresis loop for soft and hard magnetic materials. Discuss energy product, and maximum energy product.	(1). Set up for B-H curve, experimental material (commercial Nickel), CRO and connecting leads	Determine the B-H curve and to find out the values of coercivity, retentivity and saturation magnetization of experimental material. (Commercial Nickel).	Direct the students to determine the B-H curve and to find out the values of coercivity, retentivity and saturation magnetization of experimental material. (Commercial Nickel).	and mutual inductance of circuits. Direct students to derive an expression for the energy stored in an inductor and total magnetic energy of the system current. Direct the students to explain hysteresis losses in ferromagnetic materials and the hysteresis loop for soft and hard magnetic materials
General Objectives 2.0 Apply Maxwell's equations and their solutions						
	2.1 State equation of continuity. 2.2 Interpret the equation in terms of conservation of charge.	Show equation of continuity and Interpret the equation in terms of conservation of	Lecture notes and reference materials and texts.			Ask the students to state the equation of continuity in terms of

	2.3 Define displacement current and displacement current density. 2.4 State the differential form of Ampere's Law. 2.5 Modify Ampere's Law for currents changing with time. 2.6 Derive the four Maxwell equations. 2.7 Explain the physical significance of each of the Maxwell's equation. 2.8 Apply Maxwell's equations to fields varying rapidly with time. 2.9 State an example in which fields change rapidly with time. 2.10 Explain electromagnetic radiation in terms of rapidly changing fields. 2.11 Describe electromagnetic radiation.	charge. Explain displacement current and displacement current density. State the differential form of Ampere's Law and its modification for current change with time. Show how to drive the four Maxwell equations. State the physical significance of each of the Maxwell's equation. Discuss Maxwell's equations to fields varying rapidly with time. Show an example in which fields change rapidly with time.	-do-			conservation of charge. Direct the students to define displacement current and displacement current density and use same to solve numerical problems. Ask the students to state the differential form of Ampere's Law and its modification for current change with time. Direct the students to apply Maxwell's equations to fields varying rapidly with time and explain electromagnetic radiation in

		Discuss electromagnetic radiation in terms of rapidly changing fields.				terms of rapidly changing fields.
General Objectives 3.0 Outline the properties of electromagnetic waves and their propagation in free space and matter						
	3.1 State Maxwell's equation in free space 3.2 Solve Maxwell's equation in free space. 3.3 Show that the solution of Maxwell's equation in free space corresponds to waves with speed of light. 3.4 Show that the speed of light in free space is related to μ_o and ϵ_o (permeability and permittivity of free space). 3.5 Explain the important features of the electromagnetic field by plane waves; wave number, wavelength, period, frequency and wave velocity. 3.6 Explain polarized plane wave. 3.7 State the expression for linearly polarized plane wave. 3.8 Illustrate with the aid of diagrams, the relative directions of electric and	Discuss how Maxwell's equation in free space corresponds to waves with speed of light. Explain how the speed of light in free space is related to μ_o and ϵ_o (permeability and permittivity of free space.) State the important features of the electromagnetic field by plane waves; wave number, wavelength, period, frequency and wave velocity. State polarized plane wave.	Lecture notes and reference materials and texts. -do-			Ask the students to state Maxwell's equation in free space and show how Maxwell's equation in free space corresponds to waves with speed of light. Direct the students to explain the important features of the electromagnetic field by plane waves; wave number, wavelength, period, frequency and wave velocity. Direct the

	magnetic field vectors in a plane wave. 3.9 Derive the relation between the electric and magnetic fields in the electromagnetic wave. 3.10 Define the refractive index of the medium. 3.1 Calculate the energy in an electromagnetic wave. 3.2 Define [i] poynting vector [ii] wave group [iii] wave velocity, [iv] phase velocity [v] group velocity. 3.3 Determine the attenuation of plane waves in conductors. 3.4 Explain the skin effect. 3.5 Describe the absorption of plane waves in insulators. 3.16 Define absorption index.	Show the expression for linearly polarized plane wave. Describe with the aid of diagrams, the relative directions of electric and magnetic field vectors in a plane wave. Show how to derive the relation between the electric and magnetic fields in the electromagnetic wave. Explain the refractive index of a medium. Explain how to calculate the energy in an electromagnetic wave. Give the definition: [i] poynting vector [ii] wave group [iii] wave velocity,	Lecture notes and reference materials and texts.			students to state the expression for linearly polarized plane wave, show diagrammatically the relative directions of electric and magnetic field vectors in a plane wave and derive the relation between the electric and magnetic fields in the electromagnetic wave. Ask the students to explain the attenuation of plane waves in conductors and describe the absorption of plane waves in insulators

		[iv] phase velocity [v] group velocity. Give the definition of the absorption of plane waves in insulators.				
General Objectives 4.0 Outline the propagation of high frequency signals along transmission lines						
	4.1 Define a transmission line. 4.2 Define [i] a lossy line, and [ii] a loss less line. 4.3 Explain the properties of loss line. 4.4 Write the [i] current and [ii] voltage equation for a wave traveling along a line. 4.5 Describe commonly used line e.g. coaxial cables and parallel strip lines. 4.6 Calculate capacitance per unit length and inductance per unit length of commonly used lines. 4.7 Derive [i] the characteristic impedance of lines; [ii] speeds of signal propagation along the line. 4.8 Explain reflections at the end of transmission lines. 4.10 Explain standing waves along the lines. 4.10 Calculate voltage standing	Give the definition of; [i] transmission line [ii] a lossy line [iii]a loss less line. Explain the properties of loss line Provide the; [i] current and [ii] voltage equation for a wave traveling along a line. Describe commonly used line e.g. coaxial cables and parallel strip lines. Show how to calculate capacitance per unit length and inductance per unit	Lecture notes and reference materials and texts.			Ask the students to define a transmission line, a lossy line, a loss less line. Ask the students to state the equations of current and voltage for a wave traveling along a line. Solve numerical problems. Direct the students to derive the characteristic impedance of lines; speeds of signal

	wave ratio. 4.11 Explain mismatched transmission line. 4.12 Explain impedance matching. 4.13 Explain transmission lines as high frequency circuit.	length of commonly used lines. Describe reflections at the end of transmission lines and standing waves along the lines Describe mismatched transmission line, impedance matching, and transmission lines as high frequency circuit.	Lecture notes, reference texts and materials.			propagation along the line. Ask the students to write short note on mismatched transmission line, impedance matching and transmission lines as high frequency circuit.
General Objectives 5.0 Outline the propagation of high frequency signal wave - guides						
	1.1 Define wave guides 1.2 Describe wave-guides in common sense. 1.3 Compare a wave-guide with an antenna in transmitting waves. 1.4 Describe the propagation of waves between conducting planes. 1.5 Explain the reflection and transmission of electromagnetic wave. 1.6 State the boundary	Discuss wave-guides in common sense and with an antenna in transmitting waves. Explain the propagation of waves between conducting planes. Describe the reflection and	Lecture notes, reference texts and materials.			Direct the students to discuss wave-guides in common sense and with an antenna in transmitting waves. Ask the students

	conditions. 1.7 Define transverse electromagnetic waves. 1.8 Write an expression for acceptance propagation mode. 1.9 Define [i] cut-off frequency modes [ii] wave guide number and [iii] guide wavelength. 1.10 Explain the characteristics of the waves that can travel down a rectangular wave-guide. 5.10 Write the wave-guide equation. 5.11 Write expressions for transverse electromagnetic wave. 5.12 Explain how T_{m01}, T_{M10}, modes vanish in rectangular wave-guide. 5.13 State the losses in practical wave-guides. 5.14 Describe the basic structure of a cavity resonator (reflex klystron or magnetron). 5.15 Calculate the resonant frequency of a rectangular cavity. 5.16 State expressions for both electric and magnetic fields in the cavity.	transmission of electromagnetic wave. Discuss transverse electromagnetic waves. State the expression for acceptance propagation mode. Give the definitions of cut-off frequency modes, wave-guide number and guide wavelength. Describe the characteristics of the waves that can travel down a rectangular wave-guide. Describe how T_{m01}, T_{M10}, modes vanish in rectangular wave guide and state the losses in practical	-do- Lecture notes and reference materials and texts. -do-			to explain the propagation of waves between conducting planes and explain reflection and transmission of electromagnetic wave. Ask the students to discuss the characteristics of the waves that can travel down a rectangular wave-guide and give expressions for transverse electromagnetic wave. Solve numerical problems. Direct the students to discuss how T_{m01}, T_{M10}, modes vanish in rectangular wave

	5.17 Explain how [i] transverse electric [TE], [ii] transvers magnetic [TM] and Transverse electromagnetic [TEM] wave modes are obtained in the cavity. 5.18 List the different uses of cavities.	wave-guides. Describe the basic structure of a cavity resonator (reflex klystron or magnetron).				guide. To Ask the students to state basic structure of a cavity resonator (reflex klystron or magnetron) and give expressions for both electric and magnetic fields in a cavity.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Analogue Electronics	**Code:** PYE 323	**Contact Hours:** 4 Hours/week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** Second	**Practical:** 2 Hours/week

Course main Goal: The course is designed to provide students with knowledge and skills that would enable them design different types of transistor amplifiers.

General Objectives:

On completion of the course, the student should be able to:

1.0 Outline the construction, characteristics and uses of different semiconductor diode
2.0 Outline the constructional features, characteristics and uses of various transistors
3.0 Comprehend the analysis and parameters of common-emitter single stage transistor amplifiers
4.0 Comprehend the analysis and parameters of common-Emitter single stage transistor Amplifiers
5.0 Comprehend the analysis and parameters of single stage amplifiers with high input impedance
6.0 Comprehend the frequency response of RC coupled amplifiers
7.0 Comprehend the Concept of Multistage Amplifiers
8.0 Comprehend the concept of Small Signal Turned Amplifier
9.0 Comprehend the Concept of Direct Coupled Amplifiers
10.0 Comprehend the concept of Power Amplification
11.0 Outline the working principles and applications of the operational amplifier

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Analogue Electronics			**Code:** PYE 324		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 327		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Outline the construction, characteristics and uses of different semiconductor diode						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Semiconductor diode 1.1 List types of diodes and their symbols (i.e. p-n junction diode, breakdown (zener) diode, Tunnel (Esaki) diode, photodiodes, and light emitting diodes) 1.2 Describe the construction and V-I characteristic of [i] P-N Junction diode [ii] Tunnel diodes and [iii] Photodiode 1.3 State the uses of the various types of diodes listed in 1.2 above. 1.4 Compare V-I characteristics of Silicon and germanium diodes under forward and reverse biased conditions. 1.5 Describe an	Explan the principle of operation of (i) p – n junction diode. (ii) Tunnel diodes (iii) photodiode. Explain the V-I characteristics of diodes under forward and reverse biased conditions. Solve problems involving diode equation. Give practical applications of diodes. Give practical applications of diodes.	**Textbook** Diodes of different types: junction diode, photodiodes, tunel diodes, Zener diodes, silicon diode, germanium diode etc DC Power supply unit or battery, signal generators, connecting wires, bread board.	Determine the static and dynamic characteristics of a silicon diode (general purpose diode) Investigate the working of the diode as a limiter and clamper. Determine zener diode characteristics. Investigate the working of a diode in single phase, half-wave and full wave rectification.	Set up experiment to determine the VI characteristics of a junction Set up experiment to compare the VI characteristics of silicon and germanium Conduct practical to determine the characteristics of diodes, and investigate their use on half wave and full wave rectifier	Explain the process for formation of PN junction from P type and N type materials Outline the differences in the VI characteristics of silicon and germanium diodes.

	experiment to determine V-I characteristics for silicon and germanium diodes. 1.6 Explain the diode equation. 1.7 Draw the equivalent circuit of a diode (Piecewise-linear approx) 1.8 Derive an expression for diode resistance from the diode equation. 1.9 Determine the static and dynamic resistance of a silicon diode (general purpose diode) 1.10 Describe how to determine zener diode characteristics.	Use graph to explain the difference between the AC and DC resistance of a junction diode	Lecture notes, reference texts and materials.		Connect circuit to determine the VI characteristics of a Zener diode	Why do we use zener diode as voltage regulators
General Objectives 2.0 Outline the constructional features, characteristics and uses of various transistors						
	Transistor Characteristics 2.1 List the various types of transistors and their symbols (bipolar transistors, field-effect transistors, injunction transistors and silicon controlled rectifiers	Distinguish between n-p-n and p-n-p bipolar transistors. Explain the characteristic curves for bipolar transistor in	Bipolar transistors Field effect transistors Unijunction transistors BC 107 or (108,109) power supply unit, CRO,	Measure the basic parameters (Static characteristics) of a transistor in C-E configuration. Measure the basic parameters of a transistor in the C-B configuration.	Conduct practical to measure the basic parameters of transistors in the C.E and C-B configurations	What are the advantages of the FET over the BJT. What are the practical applications UJT

	2.2 Draw circuit diagrams of properly biased P-n-P, n-p-n bipolar transistors for different configurations. 2.3 Draw characteristics curves for bipolar transistor in: [i] common base (CB) configuration [ii] common-emitter (CE) configuration [iii] and common-collector (C.C) configuration 2.4 Determine from 2.3 above the following [i] input resistance [ii] voltage gain [iii] and current gain [iv] output resistance 2.5 Measure experimentally the basic parameters of transistor in common-Emitter configuration. 2.6 Draw the hybrid (h-) parameters equivalent circuit of a bipolar transistor. 2.7 Describe the constructional	common – base, common-emitter and common-collector configurations. Solve problems on bipolar transistors. Discuss the application hybrid parameters of equivalent circuit of a bipolar transistor. Explain the principle of operation of field effect transistor (FET). Solve problems on the characteristic curve of field effect transistor. Explain the constructional factors of the Unijunction. Give practical applications of Unijunction Transistor.	multimeter (digital). Lecture notes and reference materials and texts.	Determine the characteristics of FET		

	features and equivalent circuit of the mud field effect transistor (FET) 2.8 Describe the characteristics curve of the FET in: [i] common source and [ii] common drain configuration 2.9 Describe how to determine the characteristics of FET 2.10 Describe the constructional features and characteristic curves of the injunction transistor (UJT). 2.11 Describe some applications of UJT 2.12 Describe the constructional features and characteristic curve of silicon controlled Rectifier (SCR) 2.13 Describe applications of SCR	Explain the principle of operation of silicon controlled rectifier (SCR).	Lecture notes and reference materials and texts.			
General Objectives 3.0 Comprehend the analysis and parameters of common-emitter single stage transistor amplifiers						
	Single-Stage Transistor Amplifiers	Explain the operation of a	CRO, power supply unit	Investigate the properties of a	Conduct practical to investigate the	Explain how the operating

	3.1 Draw the circuit diagrams of a common-emitter amplifier for different biasing methods. 3.2 Describe the operations of a common emitter amplifier. 3.3 Describe using the load line method: [i] the voltage gain [ii] the current gain and [iii] the power gain of a common emitter amplifier. 3.4 Draw the equivalent circuit of a common-emitter transistor amplifier using h-parameters. 3.5 Derive expressions for [i] input resistance [ii] voltage gain and [iii] current gain of common emitter amplifier using 3.4 3.6 Solve numerical problems on common emitter amplifiers	single stage transistor amplifier. Discuss the importance of load line method in single-stage transistor amplifiers. Solve problems on single stages transistor amplifiers.	signal generator, probes, transistors Lecture notes and reference materials and texts.	transistor power amplifier. Determine the voltage and current gains of a C-E amplifier Investigate the effect of negative feedback on the gain and frequency response of an amplifier. Investigate the effects of positive feedback in the gain and bandwidth of transistor amplifier.	properties/parameters of transistors for amplifiers connected in CE and CB mode.	point, the dc load line, the ac load line of a single stage amplifier may be determined
General Objectives 4.0 Comprehend the analysis and parameters of single stage amplifiers with high input impedance						
	Amplifier circuits with	Explain the	Lecture notes			State the

	high inputs impedance. 4.1 Draw circuit diagram of a common collector amplifier (emitter follower). 4.2 Derive an expression for the input impedance of the common-collect using h-parameter. 4.3 State the properties of a common collector amplifier. 4.4 Describe the bootstrapping technique of increasing the input impedance of an emitter follower. 4.5 Draw the circuit diagram of a FET amplifier in common collector configuration. 4.6 State the properties of FET in 4.5 above. 4.7 Explain some applications of common collector amplifier and FET amplifiers.	circuit diagrams of a common collector amplifier (emitter follower). Give practical applications of common collector amplifier. Discuss the circuit diagram of FET in single stage amplifier.	and reference materials and texts. -do-			applications of FET amplifiers
General Objectives 5.0 Comprehend the frequency response of RC coupled amplifiers						
	Frequency response of RC coupled	Explain the RC coupled	Resistors, capacitors.	Determine the frequency response of	Conduct practical to determine the	What is the effect of the

	5.1 Describe the frequency response of typical RC coupled amplifiers. 5.2 Determine the bandwidth of an RC coupled amplifier from the frequency response curve. 5.3 Explain the effect of the coupling capacitor on the frequency response curve at low and high frequency. 5.4 Describe the effect of the emitter by-pass capacitor on the frequency response of the amplifier. 5.5 Describe how to determine the frequency response curve of an RC coupled amplifier. 5.6 Explain the RC coupled amplifier circuit. 5.7 Describe the frequency response curve of an RC coupled amplifier.	amplifier circuit. Discuss the frequency response curve of an RC coupled amplifier. Give assignments to students on RC coupled amplifier Lecture and describe how to determine the frequency response curve of an RC coupled amplifier. Give assignments to students on R-C coupled amplifier.	Lecture notes and reference materials and texts.	an RC coupled amplifier. Determine the band width of the RC coupled amplifier	frequency response of an RC coupled amplifier and the bandwidth	coupling capacitor on the frequency response of an RC coupled amplifier. Ask students to describe how to determine the frequency response curve of an RC coupled amplifier and give assignments to students on R-C coupled
General Objective 6.0 Comprehend the concept of multistage amplifiers						
	Multistage Amplifier 6.1 Define a multistage amplifier circuit.	Distinguish between single stage and	Resistors, Capacitors Transformers	Determine the frequency of: RC-coupled multistage	Conduct practical to determine the frequency of	What are the merits and demerits of an

	6.2 State the different methods of amplifier coupling e.g. RC coupling, direct coupling and transformer coupling. 6.3 Draw the circuit diagram of an RC coupled two-stage transistor. 6.4 Explain with the aid of a sketch, the frequency response of a two stage RC coupled amplifier. 6.5 Derive the relationship between the gain and band width of a multistage RC coupled amplifier 6.6 Draw the circuit diagram of a transformer coupled multistage amplifier. 6.7 Explain, with the aid of sketch, the frequency response of a transformer-coupled amplifier. 6.8 Draw the circuit diagram of a direct coupled multistage amplifier 6.9 Explain, with the aid	multistage amplifiers. Explain the frequency response curve of a two stage RC coupled amplifier. Explain the basic features of a transformer coupled multistage amplifier and direct coupled multistage amplifier. State the applications of different types of coupling in 6.2 above.	A number of transistor eg BC108, etc. Lecture notes and reference materials and texts.	amplifier, transformer coupled multistage amplifier, direct-coupled multistage amplifier.	differently coupled amplifiers	RC coupled amplifiers Compare the frequency response of the RC coupled amplifier and that of a transformer coupled amplifier Instruct the students to explain the basic features of a transformer coupled multistage amplifier and direct-coupled multistage amplifier.

	of a sketch the frequency response of direct coupled multistage amplifier 6.10 Compare the advantages and disadvantages of different types of coupling in 6.2 above.					Ask student to compare the advantages and disadvantages of different types of the different types of coupling
General Objective 7.0 Comprehend the concept of small signal tuned amplifier						
	Small Signal Tuned Amplifier 7.1 Draw the circuit diagram of a tuned transistor amplifier 7.2 Describe the operation of a tuned amplifier. 7.3 Calculate the resonant frequency of the tuned circuit. 7.4 Draw the circuit diagram of a double tuned amplifier circuit. 7.5 Describe the principle of operation of a double tuned amplifier. 7.6 Explain how to determine the bandwidth in tuned transistor amplifier circuits. 7.7 List areas of	Explain with the aid of a sketch, the operation of a tuned amplifier and double-tuned amplifier circuit. Discuss the characteristic curve of a tuned transistor amplifier circuit. Explain how to determine the bandwidth in tuned transistor amplifier	Transistors, Inductors, Capacitors, other consumables.	Determine the bandwidth in tuned transistor amplifier circuits	Conduct practical to determine the bandwidth of tuned amplifier	Ask students to explain tuned amplifier and explain the operation of a double tuned amplifier Direct the students to Explain how to determine the bandwidth in tuned transistor

	applications of tuned amplifiers e.g. [i] r. f. amplifiers in radio receiver and [ii] video amplifiers 7.8 Explain with the aid of a sketch, the operation of a tuned amplifier and double-tuned amplifier circuit. 7.9 Describe the characteristic curve of a tuned transistor amplifier circuit.	circuits.	Lecture notes, reference texts and materials.			amplifier circuits.
General Objectives: 8.0 Comprehend the concept of direct coupled amplifiers						
	Direct Coupled Amplifiers 8.1 List three class of direct coupled amplifiers [i] Darlington-connection [ii] differential amplifier [iii] operational amplifier 8.2 Draw the circuit diagram of a Darlington (pair) amplifier 8.3 Describe the operation of the circuit in 8.2 8.4 Derive expressions	Explain the principle of a Darlington (pair) amplifier. Solve problems on the h-parameters for a Darlington pair amplifier Derive	Charts and diagrams Lecture notes and reference materials and texts.			Direct to draw and explain the nature of frequency response of a direct-coupled amplifier. Ask the student to

	using h-parameters for: [i] input impedance [ii] current gain [iii] output impedance and [iv] voltage gain of a darlington pair amplifier 8.5 Describe the use of diodes to stabilize the Darlington pair amplifier 8.6 Draw the circuit diagram of a balanced differential amplifier 8.7 Describe the working principles of the balanced differential amplifier 8.8 Describe with the aid of diagram the working principles of the unbalanced differential amplifier. 8.9 Explain the determination of common-mode rejection ratio (CMRR) of a differential amplifier	expressions using h-parameters for: [i] input impedance [ii] current gain [iii] output impedance and [iv] voltage gain of a Darlington pair amplifier Describe with the aid of diagram the working principles of a balanced differential amplifier and an unbalanced differential amplifier.	Lecture notes and reference materials and texts.			derive expressions using h-parameters for: [i] input impedance [ii] current gain [iii] output impedance and [iv] voltage gain of a Darlington pair amplifier Instruct the students to describe with the aid of diagram the working principles of a balanced differential amplifier and an unbalanced differential amplifier.
General Objectives: 9.0 Comprehend the concept of power amplification						
	Power Amplifiers 9.1 Explain the	Explain each class of power	Transistors and other	Determine the efficiency of class A	Conduct practical to determine efficiency	Compare the efficiency of

	importance of large signal amplification. 9.2 Explain the classification of power amplifiers i.e. [i] class A mode [ii] class B mode [iii] class AB mode and [iv] class C mode 9.3 Describe the method of determining the power output and the efficiency of an amplifier. 9.4 Describe the operation of the push-pull power amplifiers in the: [i] class A mode [ii] class B mode and [iii] class AB mode 9.5 Compare the merits and demerits of classes of push-pull power amplifiers listed in 9.4 above.	amplifiers. Illustrate the working principle of the push-pull amplifiers with suitable circuit diagrams. State the practical application of classes of push pull power amplifiers.	consumables Lecture notes and reference materials and texts.	transistor power amplifier Determine the efficiency of class B transistor power amplifier	of class A and class B power amplifiers	class A and class B amplifiers Describe the operation of the push-pull power amplifiers in the: [i] class A mode [ii] class B mode and [iii] class AB mode and Compare the merits and demerits of classes of push-pull power amplifiers
General Objectives 10.0 Comprehend the concept of Feedback as it affects the performance of the transistor amplifier						
	Negative Feedback Amplifier 10.1 Define feedback 10.2 Derive an expression for voltage gain in negative feedback amplifier.	Explain with the aid of diagram the negative-fed back amplifiers. State the applications of negative-	Lecture notes and reference materials and texts.			

	10.3 Explain the effect of feedback on [i] voltage gain [ii] distortion [iii] band width [iv] input impedance [v] and [vi] output impedance. 10.4 Classify, using black diagrams negative feedback into: [i] series voltage feedback [ii] series current feedback [iii] parallel voltage feedback and [iv] parallel current feedback 10.5 Describe with the aid of circuit diagrams, negative feedback amplifiers listed in 10.4	feedback amplifiers listed in 10.4.	Lecture notes, reference texts and materials.			Instruct students to explain with the aid of diagram the negative-fed back amplifiers. State the applications of negative-feedback amplifiers
General Objective 11.0 Outline the working principles and applications of the operational amplifier						
	11.1 Describe the basic operational Amplifier (OP AMP) with aid of block diagram. 11.2 Explain the characteristics of voltage operational Amplifiers. 11.3 Describe the characteristics of OP AMP in the inverting	Explain the working principle of operational amplifiers. Illustrate the characteristics of OPAMP with the aid of diagrams. Use the	Drawings and charts			Explain how the operational amplifier may be used as an integrator and as a differentiator.

	and non-inverting modes. 11.4 Explain the concept of virtual ground in OP AMP. 11.5 Write the expression for the gain of OP AMP for differential input. 11.6 Write the expression for the input and output impedance. 11.7 Define the voltage supply rejection ratio. 11.8 Describe the frequency response of an OP AMP. 11.9 Define the following terms: [i] input off – set voltage [ii] input bias current and [iii] slow rate 11.10 Explain the following OP AMP parameters, i.e. open loop voltage gain, output resistance without feedback, differential input resistance, input offset voltage, input bias current and input offset current, common mode	expressions derived in 11.5 and 11.6 to solve problems on OPAMP. Discuss the importance of OP-AMP parameters listed in 11.9 and 11.10. Explain the OP-AMP specifications in the manufacturers' data sheet.	Lecture notes, reference texts and materials. -do-			Direct the students to explain the following OP AMP parameters and OP-AMP specifications in the manufacturers'

	rejection ratio, and slow rate. 11.11 Explain the manufacturer's data specification for an OP AMP in terms of [i] the rated output [ii] power dissipation [iii] input overload protection [iv] supply current drain and [v] amplifier noise 11.12 Describe the effect of cross-over distortion in the design of equipment using operational amplifier 11.13 Explain the use of OP AMP as: [i] an integrator [ii] a differentiator [iii] an instrument amplifier [iv] current to voltage converter and [v] precision voltage regulator etc.	Explain how to minimize crossover distortion in operational amplifier. Illustrate with the aid of diagrams, the connection of OP-AMP as listed in 11.13. Discuss the applications of OP-AMP in practical systems.	Lecture notes, reference texts and materials.			data sheet giving examples Direct the students to explain how to minimize crossover distortion in operational amplifier. Ask the students to discuss the applications of OP-AMP in practical systems.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH

ELECTRONICS)		
Course Title: Telecommunication Principles	**Code:** PYE 324	**Contact Hours:** 4 Hours/week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** Second	**Practical:** 2 Hours/week

Course Main Goal: this course is designed to enable students develop skills in handling transmission of information by various technologies.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate the electromagnetic spectrum as applied to telecommunications
2.0 Recognize the relationship between transmission lines and modulated signal
3.0 Apprehend how binary information is transmitted as a digital signal
4.0 Recognize how an analogue signal is converted to a digital signal
5.0 Recognize the concept of signal multiplexing

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Telecommunication Principles		**Code:** PYE 324		**Credit Unit:** 2 Units		
Course specifications: Theoretical contents		**Practical Code:** PYE 327		**Contact Hours:** 2 Hours/Week		
General Objective 1.0 Appreciate the electromagnetic spectrum as applied to telecommunications						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Describe the physical properties of electromagnetic radiation and the relationship between frequency and wavelength. 1.2 List the principal bands of the	Show the classification of the electromagnetic spectrum indicating the frequencies and wavelengths	Lecture notes, reference texts and materials.			List the principal bands of the electromagnetic spectrum and their associated frequencies and wavelengths.

	electromagnetic spectrum and their associated frequencies and wavelengths' 1.3 Identify the main telecommunication applications of electromagnetic radiation. 1.4 Write the mathematical expression for an amplitude modulated wave 1.5 Sketch the spectrum of an AM wave from the expression of an amplitude modulated wave	Identify the main telecommunication applications of electromagnetic radiation and write the mathematical expression for an amplitude modulated wave.				Instruct the students to identify the main telecommunication applications of electromagnetic radiation and write the mathematical expression for an amplitude modulated wave.
General Objectives 2.0 Recognize the relationship between telecommunication circuits, transmission lines and modulated radio waves						
	2.1 Identify the circuit properties (resistance, capacitance, inductance and leakage) of alternating current (AC) circuits and describe their effects on transmission lines 2.2 Design an equivalent circuit model of a transmission line using the primary line	Explain the design of equivalent transmission lines also describe the effect of circuit elements on transmission lines	Labvolt circuit board "communication transmission lines" consisting of: 50 kHz step generator with impedance of 10, 25, 50, 100 and 500 Ohms, 2, 24 meter RG-174 coax transmission lines, different loads including variable resistor, Inductors and	Measure distributed capacitance and inductance of a transmission line and obtain characteristic impedance and velocity of propagation using distributed capacitance and	Ask the students to Measure distributed capacitance and inductance of a transmission line and obtain characteristic impedance and velocity of propagation using	Direct the students to explain and write the expression for: [i] transmitted band width, and [ii] AM radiated power Ask students to

	constants 2.3 Describe characteristic impedance in transmission lines including open circuit, short circuit and matched termination 2.4 Write the expression for: [i] transmitted band width, and [ii] AM radiated power 2.5 Explain why more power resides in the carrier than in the side bands. 2.6 Define modulation index 2.7 Explain the need for transmission using: [i] DSB [ii] SSB [iii] and DSBSC [iv] SSBSC. 2.8 Explain the generation of amplitude modulated signals using appropriate electronic circuit. 2.9 Write the advantages and disadvantages: [i] DSB [ii] SSB [iii] and DSBSC [iv] SSBSC. 2.10 Explain the advantages and disadvantages of: [i] DSB [ii] SSB [iii] and	Explain and drive the expression for: [i] transmitted band width, and [ii] AM radiated power. Explain the need for transmission using: [i] DSB [ii] SSB [iii] and DSBSC [iv] SSBSC.	capacitors, Tektronix TDS2000 oscilloscope, 2 CH + EXT Trigger @ 200MHz, 1Gs/Sec, iTT 1604 high accuracy digital multimeter LAB transmission line demonstrator, dual trace oscilloscope, digital multimeter, set of patching chords, function generator (2 MHz).	inductance Investigate and study the characteristics of a transmission line including attenuation, delay, frequency response, standing waves, ac line coupling and effect of additive noise.	distributed capacitance and inductance Instruct the students to investigate and study the characteristics of a transmission line including attenuation, delay, frequency response, standing waves, ac line coupling and effect of additive noise.	design an equivalent circuit model of a transmission line using the primary line constants. Direct the students to explain the need for transmission using: [i] DSB [ii] SSB [iii] and DSBSC [iv] SSBSC.

	DSBSC [iv] SSBSC.					
General Objectives 3.0 Apprehend how binary information is transmitted as a digital signal						
	3.1 Describe the properties of digital signals including frequency, mark space ratio and triggered timing. 3.2 Describe the advantages of digital signals in terms of regeneration, accuracy and recovery. 3.3 Explain why digital signals need to be modulated onto an analogue carrier. 3.4 Use keying to demonstrate how a digital signal is modulated onto an analogue carrier.	Use keying to demonstrate how a digital signal is modulated onto an analogue carrier.	Lecture notes, reference texts and materials.			Instruct the students to describe the advantages of digital signals over analogue signal.
General Objectives 4.0 Recognize how an analogue signal is converted to a digital signal						
	4.1 Identify different ways of converting [i] an analogue signal to a digital signal and [ii] digital signal to analogue signal. 4.2 Describe the advantages of digital over analog communication. 4.3 State the reasons for encoding techniques	Discus the basic steps of analogue to digital conversion process. Explain the process of encoding signals before	Digital logic trainer, dual beam oscilloscope, d.c power supply, breadboard.	Design an analog-to-digital and digital-to-analog conversion.	Direct the students to design an analog-to-digital and digital-to-analog conversion.	Explain the effect of quantization noise on transmitted signal. Calculate the signal to quantization error for a given digital signal

	and list the criteria signal encoding. 4.4 Describe the basic steps of the analog-to-digital conversion process: sampling, and quantizing/encoding 4.5 Describe linear and non-linear forms of encoding. 4.6 Explain quantization error (also called quantization noise). 4.7 Calculate signal to noise quantization errors. 4.8 Explain aliasing in telecommunication terms and how it can be overcome. 4.9 Explain the use, and limitation, of the Nyquist rule in signal sampling. 4.10 Explain digital modulation: [i] Amplitude Shift Keying (ASK) [ii] Frequency Shift Keying (FSK) [iii] Phase Shift Keying (PSK). 4.11 Describe how digital information is	transmission Describe the process of conveying information using digital modulation techniques. Explain quantization error (also called quantization noise) and calculate signal to noise quantization errors. Explain digital modulation: [i] Amplitude Shift Keying (ASK) [ii] Frequency Shift Keying (FSK) [iii] Phase Shift Keying (PSK).	1*ADC0804, 1*10uF-POL, 1*10Kohm resistance, 1*10Kohm potentiometer, 8*220ohm resistance, 8*LED. Power unit PSU, module holder base, individual control unit SIS1, experiment module MCM31, oscilloscope.	Design an analog to digital converter (ADC) circuit that converts analog input signals to corresponding binary output values. Determine ASK (Amplitude Shift Keying), FSK (Frequency Shift Keying) and PSK (Phase Shift Keying) modulation	Direct the students to Design an analog to digital converter (ADC) circuit that converts analog input signals to corresponding binary output values. Direct the students to determine ASK (Amplitude Shift Keying), FSK (Frequency	Explain why the FM requires wider bandwidth than AM. Explain quantization error (also called quantization noise) and calculate signal to noise quantization errors. Direct students to explain digital modulation: [i] Amplitude Shift Keying (ASK) [ii] Frequency Shift Keying (FSK) [iii] Phase Shift Keying (PSK).

	conveyed using various digital modulation techniques (ASK or OOK, FSK, PSK and QAM) and recognize their waveforms, and constellations. 4.12 Calculate the bandwidth of an ASK, OOK, FSK, PSK, or QAM signal. 4.13 Write expression for frequency Modulated waveform. 4.14 Explain the following terms in relation to FM waveform [i] frequency deviation, [ii] radiated power [iii] frequency swing and [v] band width. 4.15 Explain why frequency modulated (FM) signal requires wider bandwidth than amplitude modulated (AM) signal. 4.16 Sketch the spectrum of an FM waveform. 4.17 State the advantages and disadvantages of FM over AM.	Solve numerical examples involving the bandwidth of an ASK, OOK, FSK, PSK, or QAM signal and write expression for frequency Modulated waveform. Explain why frequency modulated (FM) signal requires wider bandwidth than amplitude modulated (AM) signal and sketch the spectrum of an FM waveform	Lecture notes, reference texts and materials. -do-	and demodulation	Shift Keying) and PSK (Phase Shift Keying) modulation and demodulation	Ask the students to calculate the bandwidth of an ASK, OOK, FSK, PSK, or QAM signal using numerical numbers and write expression for frequency Modulated waveform. Instruct students to explain why frequency modulated (FM) signal requires wider bandwidth than amplitude modulated (AM) signal and sketch the spectrum of an FM waveform.
General Objectives 5.0 Recognize the concept of signal multiplexing						

	5.1 Define multiplexing 5.2 Explain multiplexing techniques: [i] frequency division multiplexing (FDM), [ii] wavelength division multiplexing (WDM), and [iii] time division multiplexing (TDM) [iv] code division multiplexing [v] orthogonal frequency division multiplexing and [vi] space division multiplexing. 5.3 Explain different types of TDM [i] synchronous, [ii] asynchronous TDM, [iii] interleaving TDM and [iv] statistical TDM. 5.4 Explain the difference between analogue and digital multiplexing. 5.5 State the advantages and applications of multiplexing.	Elucidate different multiplexing techniques and their specific areas of application	Lecture notes, reference texts and materials. Lecture notes, reference texts and materials.			Explain how the concept of multiplexing is applied in telecommunication.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Physical Optics	**Code:** PYE 325	**Contact Hours:** 4 Hours/week

Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** Second	**Practical:** 2 Hours/week

Course main Goal: this course is enable students apply the knowledge of the nature of light in solving problems in engineering and astronomy.

General Objectives

On the completion of the course, the student should be able to:

1.0 Appreciate the nature of waves and wave theory
2.0 Recognize interference of light waves
3.0 Comprehend diffraction of light waves
4.0 Appreciate polarization of light waves
5.0 Recognize superposition of light
6.0 Apprehend the concept of dispersion

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Physical Optics			**Code:** PYE 326		**Credit Unit:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 327		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Appreciate the nature of waves and wave theory						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Explain the wave nature of matter. 1.2 Describe measurements of the speed of light: [i] Roemer method and [ii] Fizeau's technique. 1.3 Derive the equation of wave propagation. 1.4 Derive the linear wave equation 1.5 Explain Huygens's	Describe methods of measurement of speed of light by (i) Roemer method and (ii) Fizeau's technique. Discuss proof of the transverse nature of light	Lecture notes, reference texts and materials Spectrometer, Michaelson Interferometer	Measure wavelength of light using Young's double slit experimental kits Compare wavelengths using interferometer Determine wavelength of light with grating.	Conduct a demonstration on the use of spectrometer and interferometer	Describe the wave nature of light Explain Huygens's principle. Describe three-

	principle. 1.6 Derive the wave equation from Maxwell's equations. 1.7 State the attributes of a one-dimensional wave. 1.8 Describe three-dimensional plane waves. 1.9 Show proof of the transverse nature of light waves. 1.10 Explain energy and momentum density of light. 1.11 State the laws of Reflection and Refraction at Planar surfaces. 1.12 Explain reciprocity principle. 1.13 Explain dispersion by Prisms: prism spectrometer. 1.14 Describe the application of Huygens' principle applied to reflection and refraction: 1.15 Explain refractive index, total internal reflection and critical angle. 1.16 Explain fiber optics. 1.17 Explain [i] Light intensity and [ii] absorption of transmitted light.	waves. Explain energy and momentum density of light. Explain refractive index, total internal reflection and critical angle Describe the application of Huygen's principle applied to reflection and refraction of light waves. Explain light intensity and absorption of transmitted light.	Monochromatic source of light (source of sodium light), a plano-convex lens C, an optically plane glass plate P, an optically flat glass plate G inclined at an angle of 45◦, a travelling microscope with measuring scale and a spherometer. Optical bench with uprights, sodium lamp, biprism, convex lens, slit and micrometer eyepiece are already fitted on the optical bench.	Determine the wavelength of sodium light by Newton's Ring Determine the wavelength of sodium light using Frenel's biprism Determine the refractive indices of liquids of different concentration using laser beam by method of displacement Determine the refractive indices of liquids of	Direct the students to determine the wavelength of sodium light by Newton's ring method Instruct the students to determine the wavelength of sodium light using the fresnel's biprism. Direct students to determine of the refractive index (n) of	dimensional plane waves. Show proof of the transverse nature of light waves

	1.18 State Fermat's principle.		Mercury lamp (as source of white light), spectrometer, prism, Spectrometer accessory kits	concentration using Abbe refractometer. Measurement of angle of rotation caused by passing polarized light through an optically active substance using polarimeter. Determine the refractive indices and dispersions of flint glass and crown glass using a spectrophotometer Determine the refractive index (n) of the material of a prism using spectrometer	the material of a prism using spectrometer	
General Objectives 2.0 Recognize interference of light waves						
	2.1 Explain the term interference and state the conditions for interference. 2.2 State superposition principle and explain Superposition of two plane waves. 2.3 Explain group velocity of a wave packet. 2.4 Explain the principles	Describe the term interference and state the conditions for interference. State superposition principle and explain Superposition of two plane waves.	Young's double slit apparatus	Determine the diameter of a fine wire by interference fringes Demonstrate Young's double-slit experiment.	Conduct practical on interference fringes and young double slit measurement	Ask the students to [i] describe the term interference and state the conditions for interference [ii] State

	of Young's double-slit experiment. 2.5 Explain intensity distribution of the double-slit interference pattern. 2.6 Explain the concept of phasor addition of waves. 2.7 Describe phasor diagrams for two coherent sources. 2.8 Explain three-slit interference pattern. 2.9 Explain interference from N – Slits. 2.10 State the principle of Fresnel's biprism. 2.11 Explain interference in thin films. 2.12 Explain [i] Newton's ring, [ii] Fringes of equal thickness, the wedge. 2.13 Explain an interferometer: Michelson interferometer 2.14 Explain the determination of wavelength □ and d□ using Michelson interferometer.	Describe the principles of Young's double-slit experiment and explain intensity distribution of the double-slit interference pattern. Describe the concept of phasor addition of waves and explain phasor diagrams for two coherent sources Explain three-slit interference pattern and interference from N – Slits. Differentiate between circular fringes and localized (straight) fringes. Explain interferometer and	Sodium light source, blank paper, two plane, parallel glass plates, ruler, micrometer, 10 cm focal length lens. Glass block, microscope slide, thin glass plate, sodium burner or flame, travelling microscope, stand and clamp, convex lens and holder, menthylated spirit and clean rag. Adjustable narrow slit illumination by sodium light (sodium lamp or flame), length of	Determine the thickness of a thin film and examine the relationship between the index of refraction of a thin film and the wavelength of light incident on the film. Determine the thickness of paper by measurements on the interference fringes in an air wedge. Determine the diameter of fine wire by interference fringe measurements	Ask the students to determine the thickness of a thin film and examine the relationship between the index of refraction of a thin film and the wavelength of light incident on the film. Ask the students to determine the thickness of paper by measurements on the interference fringes in an air wedge. Direct the students to determine the diameter of fine wire by	superposition principle and explain Superposition of two plane waves. Direct the students to describe the concept of phasor addition of waves and explain phasor diagrams for two coherent sources Ask the students to explain three-slit interference pattern and interference from N – Slits. Instruct the students to explain

		with the aid of a diagram describe Michelson interferometer interference	fine copper wire suspended from a stand and held tautly vertical by attaching a small mass at the end, venier reading microscope.		interference fringe measurements	interferometer and with the aid of a diagram describe Michelson interferometer interference
General Objectives 3.0 Comprehend diffraction of light waves						
	3.1 Explain the term diffraction. 3.2 Explain diffraction phenomena: [i] Fresnel and [ii] Fraunhofer diffraction. 3.3 Explain Fraunhofer diffraction of a single slit. 3.4 Explain intensity of the single-slit diffraction pattern. 3.5 Explain intensity of two-slit diffraction pattern. 3.6 Explain resolution of single-slit and circular aperture. 3.7 Explain diffraction grating. 3.8 Describe missing orders. 3.9 Explain resolving power of [i] diffraction grating, [ii] Power of a Telescope, [iii]	Explain different methods of achieving and demonstrating diffraction of light and formation of spectra in gratings. Explain diffraction grating and describe missing orders. Explain resolving power of [i] diffraction grating,	Spectrometer, diffraction grating, sodium light. He-Ne laser, Single Slit, Screen, Scale, tape He-Ne laser, Single Slit, Screen, Scale, tape Diffraction grating, spectrometer, mercury (Hg)	Determine the wavelength of sodium light using a diffraction grating. Determine the slit width of single slit by using He-Ne Laser Determine the slit width of double slit by using He-Ne Laser Determine the wavelength of spectral lines of	Explain the different methods of achieving and demonstrating diffraction of light and formation of spectra in gratings. Direct the students to determine the slit width of single slit by using He-Ne Laser Direct the students to determine the slit width of	Ask the students to determine the wavelength of sodium light using a diffraction grating. Instruct the students to explain diffraction grating and describe missing orders. Ask students to explain resolving power of [i]

	microscope [iv] prism. 3.10 Describe the formation of spectra in grating.	[ii] Power of a Telescope, [iii] microscope [iv] prism.	source, spirit level, reading lens. Telescope with a rectangular adjustable slit, cardboard with narrow strips on it and meter scale. Spectrometer, lamp holder, spectral lamp, power supply for spectral lamps, prism, 60 degrees, hollow prism, diffraction grating, glycerol 250 ml, cyclohexene for synth. 500 ml, wash bottle, plastic 250 ml, bench clamp, and stand tube. Spectrometer, diffraction grating, mercury vapour lamp, spirit level.	mercury (Hg) source using diffraction grating and spectrometer. Determine the resolving power of a telescope. Determine the resolving power of glass prism from the dispersion curve. Determine the wavelength of a given source of light by using the diffraction grating in the normal incidence method.	double slit by using He-Ne Laser Direct the students to determine the wavelength of spectral lines of mercury (Hg) source using diffraction grating and spectrometer. Direct the students determine the resolving power of a telescope. Ask the students to determine the resolving power of glass prism from the dispersion curve. Ask the students to determine the	diffraction grating, [ii] Power of a Telescope, [iii] microscope [iv] prism.

					wavelength of a given source of light by using the diffraction grating in the normal incidence method.	
General Objectives 4.0 Appreciate polarization of light waves						
	4.1 Explain polarization of light waves. 4.2 Explain polarization by selective absorption: Malus's law. 4.3 Explain polarization from dichroic materials. 4.4 Explain polarization by reflection: derive Brewster's Law. 4.5 Explain polarization by double refraction. 4.6 Describe birefringence. 4.7 Explain birefringence and circular polarization. 4.8 Describe Nicol Prism. 4.9 Explain polarization by scattering. 4.10Explain practical and Ideal polarizers. 4.11Explain [i] optical activity and [ii] Photo-elasticity. 4.12 Explain applications of polarized light.	Describe different forms of polarization and applications. Describe birefringence and explain birefringence and circular polarization. Differentiate between practical and Ideal polarizers. Explain [i] optical activity and [ii] Photo-elasticity.	He-Ne laser with built in power supply, Stand for laser, polarizer and analyzer, quarter wave plate, laser detector (Photo device) with measuring devices (digital micro-ammeter). Screen and optical bench with suitable uprights. A diode laser, a polarizer-analyzer pair, photo detector, detector output measuring unit (micro ammeter), dial fitted to the polarizer and an optical bench.	Determine the nature of polarization of laser light using photocell and quarter wave plate. Determine the relationship between the intensity of the transmitted light through analyzer and 'θ', the angle between the axes of polarizer and analyzer and to verify Malus Law.	Direct the students to determine the nature of polarization of laser light using photocell and quarter wave plate. Direct the students to determine the relationship between the intensity of the transmitted light through analyzer and 'θ', the angle between the axes of polarizer and analyzer and to	Direct the students to describe birefringence and explain birefringence and circular polarization Ask the students to differentiate between practical and Ideal polarizers.

		Explain applications of polarized light.	He laser, dial fitted polarizer, photo detector, micro ammeter, rotational mount, glass plate, constant power supply.	Determine the Brewster's angle for glass using a polarized monochromatic light source.	verify Malus Law. Direct the students to determine the Brewster's angle for glass using a polarized monochromatic light source.	Explain [i] optical activity and [ii] Photo-elasticity. Explain applications of polarized light.
General Objectives 5.0 Recognize the principles of superposition of light waves						
	5.1 Add simple sinusoidal waves 5.2 Explain the superposition of many waves with random phases. 5.3 Describe complex waves. 5.4 Explain the use of Fourier analysis in resolving complex wave patterns into simple components. 5.5 Explain group velocity	Discuss the super position of many waves with random phases. Explain complex waves. Discuss the use of Fourier analysis in resolving complex wave patterns.	Lecture notes and reference texts.			Direct students to explain superposition of many waves with random phases.
General Objectives 6.0 Apprehend the concept of dispersion						
	6.1 Explain dispersion of a prism. 6.2 Explain normal dispersion. 6.3 Explain atomic polarizability. 6.4 Derive Cauchy	Discuss polarization by reflection. Explain polarization angle and Brewster's law.	Spectrometer, prism, mercury vapour lamp, spirit level and reading lens.	Estimate the refractive index and study of dispersion relation of a given prism using a spectrometer.	Ask the students to estimate the refractive index and study of dispersion relation of a given prism	

	dispersion equation. 6.5 Anomalous dispersion. 6.6 Drive Sellmeier's dispersion equation. 6.7 Effects of absorption on dispersion. 6.8 Explain wave and group velocity in the medium. 6.9 Describe the complete dispersion curve of a substance. 6.10 Derive electromagnetic equations for transparent media. 6.11 Explain theory of dispersion. 6.12 Explain nature of the vibration particles and frictional forces.	Explain polarization by a pile of plates. Explain polarization by diachronic crystals. Explain double refraction. Discuss polarization by scattering. Calculate problems in 7.9.	Spectrometer, prism, mercury vapor lamp etc.	Determine the dispersive power of a material of prism using spectrometer	using a spectrometer. Direct the students to determine the dispersive power of a material of prism using spectrometer	

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
COURSE TITLE: Quantum Mechanics	**Code:** PYE 326	**Contact Hours:** 2 Hours/week
Credit unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 1	**Semester:** Second	**Practical:** 0 Hours/week

Course main Goal: this course is designed to enables students study the experimentally based foundational postulates of Quantum systems and learn to solve the Schrodinger equation for non-relativistic quantum systems and become conversant in the language of Quantum mechanics, and its place in the 21st century.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Comprehend the concepts of Schrodinger equation and the operators.
2.0 Comprehend time independent Schrodinger equation.
3.0 Comprehend general discussion of bound states in an arbitrary potential.
4.0 Comprehend one-dimensional quantum mechanical problem.
5.0 Comprehend harmonic oscillator and applications.
6.0 Comprehend quantum mechanical problems and solutions.
7.0 Comprehend the applications of Schrödinger wave equation.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Quantum Mechanics			**Code:** PYE 328		Credit Unit: 2 Units	
Course specifications: Theoretical contents			**Practical Code:** None		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Comprehend the concepts of Schrodinger equation and the operators.						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Schrodinger equation and the operators 1.1 State the postulates of quantum mechanics. and derive equation of wave propagation. 1.2 Explain and derive [i] time-dependent, [ii] time-independent Schrödinger equation and dynamical evolution of a quantum state. 1.3 State and explain the properties of wave function. 1.4 Explain the interpretation of wave function probability and probability current densities in three dimensions.	Lecture Explain the concept of quantum Mechanics. Write down Schrodinger's Equation. Discuss Schrodinger's equation in relation to quantum	Lecture notes, reference texts and materials.			Ask the students to explain the postulates of quantum mechanics and derive the equation of wave propagation. Solve numerical problems using the equation. Obtain the time-dependent, time-independent Schrödinger equations and solve numerical problems using these equations.

	1.5 State the conditions for physical acceptability of wave functions. 1.6 Explain: [i] normalization [ii] linearity and [iii] Superposition principles. 1.7 Explain [i] Hermitian operator, [ii] Eigenvalues and [iii] Eigenfunctions. 1.8 Explain and derive expressions for: [i]position, [ii] momentum and [iii] Energy operators. 1.9 Explain and derive expressions for commutator of position and momentum operators. 1.10 Explain and derive expressions for expectation values of: [i] position and [ii] momentum.	mechanical system.				Direct the students to explain normalization, linearity and superposition principles.
General Objectives 2.0 Comprehend time independent Schrodinger equation						
	Time-independent Schrodinger equation 2.1 Explain [i] Hamiltonian operators, [iii] stationary states and [iii] energy eigenvalues. 2.2 Describe wave function: [i] information, [ii] importance and [iii] explanation.	Lecture Explain Hamiltonian operators, normalization of wave function.	Lecture notes and reference texts.			Direct the students to explain Hamiltonian operators, stationary states and energy eigenvalues. Ask the students to describe and explain wave function and

	2.3 Explain and derive normalization of wave function. 2.4 Explain expectation values of dynamical quantities. 2.5 Explain and derive an expression for expansion of an arbitrary wave function as a linear combination of energy Eigen functions. 2.6 Obtain the general solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states. 2.7 Explain application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets. 2.8 Explain and derive Fourier transforms and momentum space wave function. 2.9 State and explain position-momentum uncertainty principle. 2.10 Explain [i] probabilistic interpretation and [ii] expectation values. 2.11 Explain particle in a box: [i] energy levels and [ii] wave functions.	Obtain the general solution of the time dependent Schrodinger equation Explain and derive Fourier transforms and momentum space wave function. Explain position-momentum uncertainty principle. Explain hydrogen	Lecture notes and reference texts.			its importance. Explain and derive an expression for expansion of an arbitrary wave function as a linear combination of energy eigenfunctions. Solve numerical problems using the equation. Instruct the students to obtain the general solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states. Solve numerical problems using the equation. Ask the students to explain electron spin; exclusion principle.

	2.12 Explain barrier penetration; tunneling: alpha decay. 2.13 Explain particle in a three-dimensional box. 2.14 Explain hydrogen atom: separation of variables; energy; angular momentum; space quantization. 2.15 Explain electron spin; exclusion principle. 2.16 Explain particle in a finite potential well; step potential: transmission and reflection probabilities.	atom: separation of variables; energy; angular momentum; space quantization.				Direct students to explain hydrogen atom: separation of variables; energy; angular momentum; space quantization
General Objectives 3.0 Comprehend general discussion of bound states in an arbitrary potential						
	3.1 Explain [i] continuity of wave function, [ii] boundary condition and [iii] emergence of discrete energy levels. 3.2 Explain application to one-dimensional problem-square well potential. 3.3 Explain quantum mechanics of [i] simple harmonic oscillator-energy levels, [ii] energy Eigen functions ground state, [iii] zero-point energy and [iv] uncertainty	Lecture Explain Bound states in an arbitrary potential. Explain quantum mechanics of simple harmonic oscillator-energy levels, energy Eigen functions ground state, zero-point energy and	Lecture notes and reference texts			Ask the students to explain continuity of wave function, boundary condition and emergence of discrete energy levels. Describe quantum mechanics of simple harmonic oscillator-energy levels, energy eigenfunctions ground state, zero-

	principle. 3.4 Explain one-dimensional infinitely rigid box-energy eigenvalues and Eigen functions. 3.5 Describe quantum dot as example; 3.6 Explain quantum mechanical scattering and tunneling in [i] one dimension-across a step potential and [ii] rectangular potential barrier.	uncertainty principle. Solve numerical examples				point energy and uncertainty principle. Solve numerical problems and give assignment and quiz.
General Objectives 4.0 Comprehend one-dimensional quantum mechanical problem						
	4.1 Explain [i] Free particle, and [ii] Particle in a box 4.2 Explain box normalization. 4.3 Derive expressions for free particle in an infinite potential well. 4.4 Derive expressions for particle in a finite potential well. 4.5 Explain the concept of potential: [i] potential with finite walls, [ii] Potential step, and [iii] Potential barrier.	Lecture Explain the concepts of one-dimensional quantum mechanical problems. Give assignments and quiz. Derive expressions for free particle in an infinite potential well. Give assignments and quiz.	Lecture notes and reference texts.			Direct the students to explain box normalization. Ask the students to explain and derive expressions for free particle in an infinite potential well.
General Objectives 5.0 Comprehend harmonic oscillator and applications						
	Harmonic oscillator and applications	Lecture	Lecture notes and			Ask the students to derive equations for

	5.1 Derive equations for linear harmonic oscillator with explanation. 5.2 Explain Her mite polynomials. 5.3 Explain oscillator wave function 5.4 Explain even and odd parity states. 5.5 Explain energy of harmonic oscillator. 5.6 Describe zero-point energy. 5.7 Explain Hamiltonian of harmonic oscillator in terms of creation and annihilation operator. 5.8 Explain eigenvalue and Eigen function of harmonic oscillator. 5.9 Explain momentum representation for oscillators. 5.10 Explain Two coupled harmonic oscillators.	Explain and derive equations for Linear harmonic oscillator. Explain eigenvalue and Eigen function of harmonic oscillator. Solve numerical problems and give assignment and quiz.	reference texts			linear harmonic oscillator. Explain Hermite polynomials, oscillator wave function, even and odd parity states. Explain eigenvalue and eigenfunction of harmonic oscillator. Solve numerical problems and give assignment and quiz.
General Objectives 6.0 Comprehend quantum mechanical problems and solutions						
	6.1 Explain and derive expression for Schrödinger equation for spherically symmetric potential. 6.2 Describe angular part of Schrodinger equation: Spherical harmonics. 6.3 Describe shapes of orbitals. 6.4 Explain radial part of	Lecture Explain and derive expression for Schrödinger equation for spherically symmetric potential. Solve	Lecture notes and reference texts.			Ask the student to derive expression for Schrödinger equation for spherically symmetric potential. Solve numerical problems and give assignment and quiz.

	Schrodinger equation and its solution for hydrogen atom, 6.5 Explain transition probabilities and selection rules.	numerical problems and give assignment and quiz				
General Objectives 7.0 Comprehend the applications of Schrödinger wave equation						
	7.1 Explain and derive expressions for a particle in one-dimensional square well. 7.2 Explain rectangular potential barrier and tunneling. 7.3 Explain spherically symmetric potential, 7.4 Describe angular momentum operators and their Eigen functions 7.5 Explain and derive expressions for Schrodinger equation for two interacting particles in spherical coordinates. 7.6 Explain free particle radial function. 7.7 Explain and derive particle in a spherical box. 7.8 Explain spherical potential well of finite depth. 7.9 Derive general results for two particles bound states. 7.10 Concept of spin, Hydrogen atom	Lecture Describe angular momentum operators and their Eigen functions Explain and derive particle in a spherical box and obtain the general results for two particles bound states.	Lecture notes and reference texts. -do-			Direct the students to derive expressions for a particle in one-dimensional square well. Describe angular momentum operators and their eigenfunctions. Solve numerical problems and give assignment and quiz

HND II SEMESTER 1

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Advanced Equipment Maintenance and Repairs	**Code:** PYE 411	**Contact Hour:** 4 Hours/week
Credit unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: this course is designed to enable students repair and maintain modern laboratory and medical equipment

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apprehend electronic components and their specifications
2.0 Analyze the layout of components on a Vero board and printed circuit Board (PCB)
3.0 Apply methods of fault finding/trouble shooting in instruments
4.0 Comprehend the generation, classification and packaging of integrated circuits
5.0 Comprehend the families of integrated circuits
6.0 Outline of major equipment to be maintained/repaired
7.0 Outline the classification of major equipment to be maintained/repaired
8.0 Outline the troubleshooting procedure of medical and laboratory instrument

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Advanced Equipment Maintenance and Repairs			**Code:** PYE 411		**Credit Unit:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 418		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 : Apprehend electronic components and their specifications						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Explain the colour codes of resistors	Explain the four and five band	Resistors, capacitors,	**Electronics Components**	Obtain the actual value of	Give the colour code of two

	and capacitors 1.2 State the areas of application of resistors. Inductors and capacitors 1.3 Explain the method of identification of semiconductor components using the JEDEC, JIS and PROELECTRON numbering systems. 1.4 Explain the method of identification of integrated circuits and logic gates.	colour coding systems on resistors and capacitors and the numbering systems on semiconductors	inductors, diodes(Zener diodes, LED, photo diodes, tunnel diodes, varactor diodes etc) transistors(BJT, UJT, FET) Silicon controlled rectifiers (SCR), ICs such as 7400, 7408, 7432 etc	*Identify the following electronic components in relation to their symbols types, rating, colour coding/values, and areas of applications: [i] resistors [ii] capacitors [iii] inductors [iv] diodes (Pn-junction, zener, tunnel, LED) [v] transistors (BJT, FET,UJT) [vi] Silicon controlled rectifier (SCR) [vii] dial [viii] Triac [ix] integrated, circuit, operational amplifier logic gates, rectifiers, regulators etc [x] transformers *Test, using appropriate instruments, the conditions of components listed in 1.1 above. *Obtain necessary information on components listed in 1.1 above using data books.	resistors using the colour codes Compare the calculated value with the observed value	resistors whose values are 20K±5% 0.5Ω±1% Fully identify the component represented by the code BC108B
General Objectives 2.0 Analyze the layout of components on vero board and printed circuit board (PCB)						
	2.1 List out different types of circuit	Explain the wiring techniques	Vero board, bread board,	*Identify different types of boards such as:	Explain the specific uses of	Why do we describe the

	boards. 2.2 Explain the areas of application. 2.3 Explain the process of conversion of circuit diagram to a layout/lay diagram. 2.4 Explain the procedure of fabricating PCB	of vero board and bread board Explain why the bread board is called the solderless board and the advantages	matrix board, PCB, Push pull amplifier circuit with associated components	[i] vero board [ii] bread board [iii] matrix board and [iv] printed circuit board (P.C.B) *Explain the specific uses of boards listed above. *Explain the layout of components on a vero board from a given circuit diagram. *Layout components on a vero board for a given circuit diagram of: [i] push-pull power amplifier stage (involving use of heat sink [ii] regulated power supply unit and [iii] digital devices (using TTL, CMOS etc) Explain the layout procedure of components on a printed circuit board for a given circuit diagram. Produce a printed circuit board (P.C.B) for any given circuit.	board listed in column 5 Explain the layout procedure of components on a printed circuit board for a given circuit diagram.	breadboard as the solderless board? What are the advantages over the vero board?
General Objectives 3.0 Apply the methods of fault finding/trouble shooting in instruments						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	3.1 Explanation of the term trouble	Explain the necessary steps in	Textbook Lab-manual,	*Demonstrate the two general methods of	Carry out experiment to	List and explain the four types of

	shooting. 3.2 Explain the general steps in trouble shooting. 3.3 Classify fault finding techniques 3.4 Explain static and dynamic tests. 3.5 Identify the forms of dynamic test such as [i] input to output [ii] output to input [iii] half split method and [iv] random test method 3.6 Explain different troubleshooting methods of [i] simple gate circuits [ii] decoding circuits and [iii] counters etc	troubleshooting. Explain the static and dynamic tests Use diagrams to explain troubleshooting procedure of logic gates and decoding circuits	data books and manufacture's manual and faulty radio receiver	fault-finding: [i] static testing (point to point testing) [ii] dynamic testing (signal injection) *Identify different functional blocks (section) of an equipment from the manufacturers' circuit diagram. *Locate test points from the manufacturers circuit diagram. *Carry out point-to-point-testing (static) on equipment such as: [i] power supply unit [ii] radio receiver and [iii] signal generator etc. *Carry out dynamic testing using signal injection on equipment listed above	determine a faulty module in an instrument. Carry out static test using multimeter to detect faulty components such as transformer, capacitor , transistor, diodes etc	dynamic test. Explain the steps in troubleshooting decoding circuits.
General objective 4.0 Comprehend the generation, classification and packaging of integrated circuits						
	4.1 Define integrated circuits. 4.2 Describe the advances and generations of integrated circuits. 4.3 Explain the classifications of	Explain method of identification of different IC families	Sample of different types and families of integrated circuits e.g. 555 timer, op amp 741, 7400 series etc.	Carry out physical identification of different families of ICs	Carry out practical on physical identification of families of ICs	Explain the steps in identifying a given IC.

	integrated circuits. 4.4 Describe the packaging of integrated circuits. 4.5 Explain the design, operation and specification of 555 timer IC. 4.6 Describe the design and operation of operational amplifiers. 4.7 Give an overview of 7400 series IC 4.8 Describe the design and operation of INTEL 4004 IC. 4.9 Explain the behaviour and derivatives of MOS 6502 IC. 4.10 Explain the operation and application of microprocessors and microcontrollers.	Identify different classes packaging and pin arrangements of ICs. Give an overview of 7400 series IC, Understand the design and operation of INTEL 4004 IC and explain the behaviour and derivatives of MOS 6502 IC.	Lecture notes, reference texts and materials.			Ask students to identify different classes packaging and pin arrangements of ICs. Direct students to give an overview of 7400 series IC, Understand the design and operation of INTEL 4004 IC and explain the behaviour and derivatives of MOS 6502 IC.
General Objectives 5.0 Comprehend trouble shooting and troubleshooting procedures of ICs						
	5.1 Explain the term Troubleshooting 5.2 Explain different troubleshooting	Explain troubleshooting and procedure of troubleshooting	Lecture notes, reference texts and materials.			Explain the steps in carrying out troubleshooting

	methods and operation of [i] simple gate circuits simple logic circuit [ii] decoding circuits and [iii] Troubleshooting counters	integrated circuits	Diagrams and charts.			
General Objectives 6.0 Outline of major equipment to be maintained/repaired						
	6.1 Classify the instruments to be maintained into: [i] optical equipment [ii] electromechanical equipment [iii] heating equipment [iv] physical measuring equipment [v] high tech equipment and [vi] separation equipment [vii] biomedical equipment 6.2 List out five equipment in each class and briefly state their uses.	Give one example of each group and explain the operation and uses	Use drawing and chart to explain the operation and uses of each			Ask students to classify the instruments to be maintained into: [i] optical equipment [ii] electromechanical equipment [iii] heating equipment [iv] physical measuring equipment [v] high tech equipment and [vi] separation equipment [vii] biomedical equipment and List out five equipment in each class and briefly state their uses.

General Objectives 7.0 Recognize the Troubleshooting procedure for laboratory and medical equipment						
	(A) Optical Instruments 7.1 List out optical instrument 7.2 Explain the working principles of instruments listed in 7.1 above 7.3 List out possible fault and their symptoms 7.4 Draw the trouble-shooting table. 7.5 Repair a sample of optical instrument eg microscope **(B) Electromechanical instruments** 7.6 List out electromechanical instruments used in the lab 7.7 Explain the working principles of the instruments listed in 7.6 7.8 List out possible faults in 7.6 above and their symptoms. 7.9 Draw the trouble	Explain the features of the named optical equipment Explain the features of the named electromechanical instrument eg centrifuge Explain the features of the named Heating instrument Laboratory incubator Explain the possible causes of	Allen keys Set of precision drivers An optical microscope Centrifuge and set of screw drivers Laboratory oven and tool kit	Identify component parts of the microscope Dismantle a microscope and clean the lenses Identify a faulty section of the centrifuge	Carry out troubleshooting of the faulty microscope Carryout test to determine the faulty part of the instrument Carryout troubleshooting exercise to determine the part (s) that had failed	Ask the students to identify and explain which parts of the microscope requires greasing at intervals Direct the students to state and describe the likely cause of the fault if the centrifuge motor rotates at a slow speed Ask the students to identify the components that may have failed if the temperature of the incubator overshoots the preset values

	shooting table 7.10 Repair a sample of an electromechanical instrument. **(C) Heating Instruments** 7.11 List out heating equipment used in the lab eg incubator, autoclave etc. 7.12 Explain the working principles of the instruments listed in 7.11 above. 7.13 List out possible faults in 7.11 above and their symptoms 7.14 Draw the trouble-shooting table. 7.15 Repair a sample of heating equipment eg. Incubator, water bath etc **(D) Physical Measuring Instrument** 7.16 List out physical measuring equipment. 7.17 Explain the working principles of the instruments listed in 7.16 above.	defect Identify the component parts of the colorimeter Identify the component parts of the instrument. Explain the symptoms of the instrument	 Tool kit and a faulty colorimeter Tool kit, multimeter and a flame photometer	Explain the features of the laboratory incubator Identify the faulty section of the oven Identify the component parts of the equipment. Troubleshoot a faulty colorimeter	 Conduct test to ascertain the cause of the defect Troubleshoot a faulty flame photometer to identify a faulty module	 Direct the students to explain what may likely cause instability in the output reading of the instrument. Ask the students to explain how a fault in the atomizer may be rectified

	7.18 List out possible faults in 7.16 above and their symptoms. 7.19 Draw the trouble-shooting table. 7.20 Repair a sample of physical measuring equipment eg. PH meter, conductivity meter, colorimeter etc. 7.21 List out some high tech analytical equipment.eg flame photometer, UV-VIS spectrophotometer, AAS etc. 7.22 Explain the working principles of the instrument listed in 7.21 above. 7.23 List out possible faults in 8.21 above and their symptoms. 7.24 Draw the troubleshooting table 7.25 Repair a sample of high tech analytical instrument eg AAS, Flame photometer, UV-VIS Spec etc. 7.26 List out some	Explain the working principles of the electrophoreses instrument. Explain the possible cause of defects in the operation of the instrument List the functional parts of the Elisa reader. Explain the fault symptoms of the instrument	A tool kit and an electrophoreses instrument Elisa reader	Identify the component parts of the equipment. Troubleshoot a faulty flame photometer	Troubleshoot the instrument using the necessary facilities Troubleshoot the instrument using the necessary facilities	Instruct the students to explain What may likely be the cause of the burning of the cellulose paper in the course of the experiment. Direct the students to what may likely be the result of instability in the output of the instrument.

	separation equipment. 7.27 Explain the working principles of the instrument listed in 7.26 above. 7.28 List out possible faults in 8.26 above and their symptoms. 7.29 Draw the troubleshooting table 7.30 Repair a sample of high tech analytical instrument eg GLC, HPLC. **(F) Biomedical Equipment** 7.31 List out some biomedical equipment. 7.32 Explain the working principles of the instrument listed in 7.28 above. 7.33 List out possible faults in 7.28 above and their symptoms.		Lecture notes, reference texts and materials.	Identify the component parts of the instrument Identify the fault in the equipment Identify the component parts of the instrument Identify the fault in the equipment		Direct students to list out possible faults and their symptoms. Ask students to draw the troubleshooting table and repair a sample of high tech analytical instrument e.g. GLC, HPLC. Direct the students to explain List out some biomedical equipment and explain the working principles of the instrument listed in 7.28 above. List out possible

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Instrumentation	**Code:** PYE 412	**Contact Hour:** 4 Hours/week
Course unit:2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: this course is designed to enable students use various electrical/electronic instruments, their construction, applications, and principles of operation, standards and units of measurements; and provide students with opportunities to develop basic skills in the design of electronic equipment.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Comprehend the classification and general uses of analogue and digital Instruments
2.0 Outline the principle of operation and application of analogue (pointer) instruments
3.0 Outline the principle of operation and application of analogue (graphical) instruments
4.0 Outline the principle of operation and application of digital instruments
5.0 Outline the characteristics of Measuring Instruments
6.0 Appreciate the composition of a measuring instrument systems
7.0 Outline the importance of static and dynamic performance of measuring systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Instrumentation		**Code: PYE** 412		**Credit Units:** 2 Units		
Course specifications: Theoretical contents		**Practical Code:** PYE 418		**Contact Hours:** 2 Hours/Week		
General Objective 1.0 Comprehend the classification and general uses of analogue and digital instruments						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**

	Analogue and Digital Instruments 1.1 Define [i] analogue instruments [ii] digital instruments. 1.2 Explain the classification of analogue instruments into: [i] Pointer – type [iii] graphical – type [iv] classify instruments into types, ie. Indicating, recording and controlling instruments. 1.3 Explain the sub-classification of analogue (pointer) instruments into: [i] electromechanical instruments and [ii] electric instruments. 1.4 List types of electromechanical instruments such as [i] moving coil instrument; [ii] moving iron instruments [iii] electrodynamics instruments [iv] rectifier instruments [v] electrostatic instruments; and [v] energy meters. 1.5 Explain the general applications of each instruments listed in 1.4 above. 1.6 List types of electronic instruments such as: [i] dc Voltmeter; [ii] ac voltmeter; [iii] null detector [iv] "Q"	Explain the difference between analogue and digital instruments. Group each type of instrument above and list out its applications. Discuss the uses of instruments in 1.6 Explain the concept of hall effect. Explain why UV, potentiometer, moving coil recorders are grouped into analogue instrument.	Textbook Lab-manual Lecture notes, reference texts and materials.		Demonstration	Direct the students to explain the differences between analogue and digital instrument. Ask the students to explain the general uses of Q meter and list types of electromechanical instruments and their general applications of each instruments. Direct students to list types of electronic and describe the general uses of each instrument listed.

	meter and [v] Hall effect devices. 1.7 Describe the general uses of each instrument listed in 1.6 above. 1.8 Classify analogue (graphical) instruments into:- (i) Moving coil recorders (ii) Potentiometer recorders; [iii] X-Y plotters (iv) UV recorders; C.R.O.					Ask the students to classify analogue (graphical) instruments.
General Objectives 2.0 Outline the principle of operation and application of analogue (pointer) instruments						
	Analogue (Pointer) Instruments 2.1 Explain the principle of operation and construction of a moving coil instrument. 2.2 Describe the application of a moving coil instrument as; [i] a galvanometer, [ii] an ammeter [iii] a voltmeter and [iv] a multimeter 2.3 Explain the principle of operation of a moving iron instrument. 2.4 Explain the application of a	Describe the mode of operation of a moving coil instrument. Relate the instruments above to ammeter, voltmeter, and multimeter.	Demonstration using charts and diagrams, Q-meter, Hall effect meter, capacitors, inductors, source of magnetic field etc.	*Determine the inductive properties of an inductor using a Q-meter. *Determine the capacitance of a capacitor using Q-meter.	Conduct practical to determine the inductive and capacitive properties of a capacitor using Q-meter Conduct practical to measure the strength of applied	Direct the students to describe the constructional features of a moving coil instrument.

	moving iron instrument as: [i] an ammeter [ii] a voltmeter and [iv] a power factor meter 2.5 Explain the principle of operation of the electrodynamics instrument. 2.6 Explain the application of the electrodynamics instrument as: [i] an Ammeter [ii] A Voltmeter [iii] a wattmeter and [iv] a power factor meter 2.7 Explain the principle of operation of the rectifier instruments. 2.8 Explain the application of the rectifier instruments as: [i] an ammeter [ii] a voltmeter and [iii] a multimeter 2.9 Explain the principle of operation of the null detector 2.10 Explain the application of the null-detector as a phase sensitive detector 2.11 Explain the principle of operation of the Q-meter 2.12 Explain the application of the Q-meter for the [i] determination of inductor properties and [ii] determination of capacitor properties	Demonstration Lecture Discuss how electrodynamics, rectifier, null detector instruments and Q-meter work. List out their uses	Explain the application of the electrodynamics instrument as: [i] an Ammeter [ii] A Voltmeter [iii] a wattmeter and [iv] a power factor meter. Explain the application of the Q-meter for the [i] determination of inductor properties and [ii] determination of capacitor properties	Determine the strength of an applied magnetic field using Hall effect meter	magnetic field	Direct the students to determine the strength of an applied magnetic field using Hall effect meter.
General Objectives 3.0 Outline the principle of operation and application of analogue (graphical) instruments						
	Analogue (graphical) Instruments:	Discuss the applications of	Cathode ray oscilloscope,	*Demonstrate in practical	Conduct practical to	Instruct the students to

	3.1 Explain the principle of operation of the moving coil recorder. 3.2 State some specifications and applications of the moving coil recorder. 3.3 Explain the principle of operation of the potentiometer recorder. 3.4 State some specifications and applications of the Potentiometer recorder. 3.5 Explain the principle of operation of the X-Y plotter. 3.6 State some specifications of the X-Y plotter. 3.7 Explain the principle of operation of UV recorder. 3.8 State some specifications and application of the UV recorder. 3.9 Explain the principle of operation of a cathode ray oscilloscope. State some specifications and application of the cathode ray oscilloscope.	Moving coil recorder, potentiometer recorder, X-Y plotter, UV recorder cathode ray oscilloscope. Explain the principle of operation of a cathode ray oscilloscope and state some specifications and application of the cathode ray oscilloscope	Signal generator Lecture notes, reference texts and materials.	terms the use of cathode ray oscilloscope * Observe the shapes of waveform using CRO Measure the frequency, amplitude and phase of a wave form using CRO	demonstrate the use of CRO to measure frequency, amplitude and phase of a waveform.	explain the operation of the potentiometer recorder. Instruct the students to explain the principle of operation of a cathode ray oscilloscope. State some specifications and application of the cathode ray oscilloscope.
General Objectives 4.0 Outline the principle of operation and application of digital instruments						
	Digital Instruments 4.1 Explain the construction and principle of operation of a digital counter 4.2 State some specifications (features) of digital counter.	Demonstration Relate frequency, period and time measurements to digital counter mechanism	Lecture notes reference texts and demonstration using diagrams and charts			Ask students to explain advantages of successive approximation ADC over the

	4.3 Explain the application of the digital counter for: [i] frequency measurement [ii] period measurement and [iii] time measurement (digital clock) 4.4 Explain the methods used for the conversion of an analogue to digital signal such as: [i] successive and approximating method (using ladder network). [ii] ramp method or voltage to time conversion technique and [iii] voltage to frequency methods. 4.5 Explain the principle of operation of a digital voltmeter. 4.6 State some characteristics of digital voltmeter. 4.7 Explain the application of digital voltmeters for d.c. Voltage measurement	Describe conversion of analogue system to digital system. Demonstration Explain the methods used for the conversion of an analogue to digital signal, the principle of operation of a digital voltmeter and state some characteristics of digital voltmeter.				ramp ADC. Direct students to explain the methods used for the conversion of an analogue to digital signal, the principle of operation of a digital voltmeter and state some characteristics of digital voltmeter.
General Objectives 5.0 Outline the characteristics of measuring instruments						
	5.1 Explain the factors affecting instrument selection e.g. accuracy precision, resolution, sensivity and range reliability, cost, static and dynamic response, environment and type of output. 5.2 Classify the causes of error in measuring system into: [i] manufacturing errors [ii]	Lecture Demonstrate and supervise. Explain the factors affecting instrument. Explain the classification of errors in measuring	Lecture notes, reference texts and materials.			Direct students to explain the classification of errors in measuring instruments.

	design errors [iii] operating error [iv] environmental errors and [v] application errors. 5.3 Explain the importance of calibration	systems.				
General Objectives 6.0 Appreciate the composition of a measuring instrument systems						
	6.1 Explain the importance of basic components of an instrument system i.e. (i) sensing element (ii) amplifying element (iii) signal modifiers or converters and (iv) display. 6.2 State examples of sensing elements (transducer) commonly used. 6.3 Describe broad classes of transducers e.g. electrical, mechanical, pneumatic etc. 6.4 Explain the principle of operation of various types of transducers. 6.5 Explain factors for selecting transducers for measuring purposes e.g. nature of measurement, environmental consideration, cost availability etc. 6.6 State examples of simple electrical, hydraulic and mechanical amplifying elements 6.7 Explain the principles of operation of each class of	Lecture with examples Explain the importance of basic components of an instrument system. Explain the term transducer and classes of transducer. Explain the factors affecting transducers. Give example of signal converters, explain the principle of operation of signal converters and give the practical application of each	Lecture notes, reference texts and materials. -do-			Direct the student to explain the need for transducers in measuring instruments and to list types of digital display methods and six types of digital display devices. Explain the operation of each. Direct students to give examples of signal converters, explain the principle of operation of signal converters and give the practical

	amplifying element listed in 2.6. 6.8 State examples of signal converters (e.g. a rack and pinion gear, a bridge circuit or charger amplifier etc.) 6.9 Explain the principle of operation of each class of signal converters in 2.8 above. 6.10 State areas of application of each type of signal converter. 6.11 State examples of display units. 6.12 Describe broad classification of display e.g. analog and digital. 6.13 Explain the principle of operation of the various types of display unit. 6.14 Describe the factors considered in selecting display unit for measuring purposes. 6.15 List the features of various types of digital display devices and digital display methods	type of signal converter. Explain the classification of and the principle of operation of the various types of display unit. Describe the factors considered in selecting display unit for measuring purposes	Lecture notes, reference texts and materials.			application of each type of signal converter. Ask students to explain the classification of and the principle of operation of the various types of display unit. Describe the factors considered in selecting display unit for measuring purposes
General Objectives 7.0 Comprehend the composition of a measuring instrument systems						
	7.1 Explain the importance of basic components of an instrument system i.e. [i] sensing element [ii] amplifying element iii] signal modifiers or converters and [iv] display. 7.2 State examples of sensing elements (transducer) commonly	Lecture with examples Explain the importance of basic components of an instrument system i.e. [i]	Lecture notes and reference texts.			Ask students to explain the importance of basic components of an instrument system i.e. [i] Sensing element

	used. 7.3 Describe broad classes of transducers e.g. electrical, mechanical, pneumatic etc. 7.4 Explain the principle of operation of various types of transducers. 7.5 Describe factors for selecting transducers for measuring purposes e.g. nature of measurement, environmental consideration, cost, availability etc. 7.6 State examples of simple electrical, hydraulic and mechanical amplifying elements. 7.7 Explain the principles of operation of each class of amplifying elements listed in 2.6. 7.8 State examples of signal converters (e.g. a rack and pinion gear, a bridge circuit or charger amplifier etc.). 7.9 Explain the principle of operation of each class of signal converters in 2.8 above. 7.10 State areas of application of each type of signal converter. 7.11 Give examples of display units. 7.12 Explain board classification of displays e.g. analog and digital. 7.13 Explain the principle of operation of the various types	Sensing element [ii] amplifying element [iii] signal modifiers or converters and [iv] display. Explain factors for selecting transducers for measuring purposes e.g. nature of measurement, environmental consideration, cost, availability etc.	-do-			[ii] amplifying element [iii] signal modifiers or converters and [iv] display. Ask students to explain factors for selecting transducers for measuring purposes e.g. nature of measurement, environmental consideration, cost, availability etc. Direct student to explain the factors

	of display unit. 7.14 Explain factors considered in selecting display unit for measuring purposes. 7.15 Explain the features of various types of digital display devices and digital display methods	Explain factors considered in selecting display unit for measuring purposes.				considered in selecting display unit for measuring purposes.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Radio Communication Principles	**Code:** PYE 413	**Contact Hours:** 1 Hours/week
Credit unit: 1 Unit	**Pre-requisite:**	**Theoretical:** 1 Hours/week
Year: 2	**Semester:** First	**Practical:** 0 Hours/week

Course main Goal: this course is designed to enable students have knowledge and understanding of the fundamental problems of radio communication in various radio propagation environments and the basics of contemporary wireless communication systems.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate frequency distribution in radio spectrum
2.0 Outline the principles of electromagnetic wave radiation
3.0 Outline the principles of radio wave propagation
4.0 Appreciate the principles of modulation and demodulation
5.0 Recognize the working principles of Radio Transmitter
6.0 Recognize the working principles of radio receiver

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Radio Communication Principles			**Code**: PYE 413		**Credit Units:** 1 Unit	
Course specifications: Theoretical contents			**Practical Code:** None		**Contact Hours:** 1 Hours/Week	
General Objective 1.0 Appreciate various frequency bands within the radio spectrum						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Radio frequency spectrum 1.2 List the frequency/wavelength ranges allocated to each of the following bands: [i] extremely low frequency (ELF), [ii] very low frequency (VLF) [iii] low frequency (LF), [iv] medium frequency (MF), [v] high frequency (HF) [vi] ultra-high frequency (UHF), [vii] super high frequency (SHF) [viii] extremely high frequency (EHF). 1.3 State the areas of application of each frequency range listed	Lecture and demonstrate. Explain the application of each frequency range in 1.2	Lecture notes, reference texts and materials.			Give assignments on 1.1, 1.2 and 1.3

	above.					
General Objectives 2.0 Outline the principles of electromagnetic wave radiation						
	2.1 Electromagnetic wave radiation and aerials. 2.2 Define an isotropic radiation. 2.3 Describe the function of an aerial as a radiation source. 2.4 Explain the current and voltage distribution of a dipole. 2.5 Define the following parameters of an aerial: [i] gain [ii] bandwidth [iii] effective radiated power [iv] radiation resistance and [v] impedance. 2.6 Explain with the aid of a sketch, radiation pattern of an aerial. 2.7 Identify various types of aerials e.g. yagi, parabolic, etc. 2.8 State the area of the aerial mentioned above. 2.9 Describe the factors guiding the choice of aerials. 2.10Explain the effect of	Lecture with worked examples. Explain what an Isotropic radiation means. Explain the parameters in 2.5 List various types of aerials and discuss factors to be considered in the choice of aerials. Discuss the importance of frequency on arial dimensions and performance.	Lecture notes, reference texts and materials. -do-			Ask students to explain electromagnetic wave radiation and aerials. State the function of an aerial as a radiation source. Direct the students to define the following parameters of an aerial: [i] gain [ii] bandwidth [iii] effective radiated power [iv] radiation resistance and [v] impedance. Explain with the aid of a sketch, radiation pattern of an aerial. Give class assignment on the factors guiding the choice of aerials.

	operating frequency on aerial dimensions and performance.					
General Objectives 3.0 Outline the principles of radio wave propagation						
	Radio Wave Propagation 3.1 Describe the following types of waves: [i] ground waves [ii] sky waves and [iii] space waves. 3.1 Describe the composition and usefulness of the troposphere in propagation. 3.2 Describe the effects of the troposphere on the propagation below $30MHz$.. 3.3 Explain the various layers of the ionosphere such as: [i] D [ii] E and [iii] F layers. 3.4 Explain the following types of operating propagation frequency: [i] critical frequency [ii] maximum frequency and [iii] optimum working frequency.	Lecture. Explain the various types and characteristics of radio waves. Discuss the importance of troposphere in radio wave propagation. Discuss the various frequencies at which radio waves can be propagated. Explain the relevance of radio wave propagation in broadcasting etc.	Lecture notes, reference texts and materials. -do-			Ask the students to describe the following types of waves: [i] ground waves [ii] sky waves and [iii] space waves. Ask the students to explain the importance of troposphere in radio wave propagation. Give class assignment on the composition and usefulness of the troposphere in propagation.

	3.6 Describe radio wave propagation for different applications such: [i} broadcasting and [ii] paint to paint communication, etc.					
General Objectives 4.0 Appreciate the principles of modulation and demodulation						
	Modulation and demodulation 4.1 Explain modulation. 4.2 Distinguish between carrier and modulating signals. 4.3 Describe the formation as: [i] an amplitude-modulated carrier [ii] a frequency-modulated carrier [iii] a pulse modulated carrier. 4.4 State the merits and demerits of AM, and FM signals. 4.5 Explain the application of AM and FM signals. 4.6 Sketch a properly labeled [i] sine wave amplitude modulated waveforms, [ii] pulse amplitude modulated waveforms. 4.7 Explain how to obtain frequency spectrum	Lecture with worked examples. Discuss modulation. Explain the types of signal carriers. List out their advantages and disadvantages. Sketch a sine wave for (i) AM wave pathern, (ii) PM wave characteristics. Explain Demodulation.	Lecture notes, reference texts and materials. -do-			Ask students to distinguish between carrier and modulating signals and to describe the formation as: [i] an amplitude-modulated carrier [ii] a frequency-modulated carrier [iii] a pulse-modulated carrier. Direct the students to sketch a properly labeled [i] sine wave amplitude modulated waveforms, [ii] pulse amplitude modulated waveforms. Ask the student to explain demodulation" as the re verse process of modulation.

	and bandwidth of an amplitude-modulated waveform produced from given (i) sine wave modulating frequency [ii] speech modulating frequencies. 4.8 Explain demodulation" as the re verse process of modulation.					
General Objectives 5.0 Recognize the working principles of radio transmitter						
	Radio Transmitter 5.1 Draw a labeled block diagram of an amplitude modulated (AM) transmitter. 5.2 Explain the function of each stage above. 5.3 Explain the significance and principles of frequency multiplication in radio transmitters. 5.4 Describe the circuit to produce AM signals. 5.5 Describe the need for an amplifier driver stage. 5.6 Describe the operation of a simple power amplifier with aerial. 5.7 Describe the operation	Lecture. Discuss the principles involved in frequency multiplication in radio transmitters. Explain the circuitry associated with amplitude – modulated signals. Discuss how a rf frequency power amplifier with aerial – amplifier arrangement.	Lecture notes, reference texts and materials. -do-			Instruct the students to draw a labeled block diagram of an amplitude modulated (AM) transmitter and explain the function of ach stage mentioned above and the significance and principles of frequency multiplication in radio transmitters. Direct the students to describe the circuit to produce AM signals, the need for an amplifier driver stage of a simple power amplifier with aerial, the operation of a

	of a simple of power amplifier with aerial coupling arrangement. 5.8 Describe practical procedures for matching an aerial to a radio transmitter.					simple power amplifier with aerial coupling arrangement and practical procedures for matching an aerial to a radio transmitter
General Objectives 6.0 Recognize the working principles of radio receiver						
	6.1 Draw a labeled block diagram of a straight radio receiver. 6.2 Describe the function of each stage of the straight radio receiver such as [i] r.f variable - tuned amplifier [ii] demodulator [iii] a.f amplifier. 6.3 Explain, with the aid of simple circuit arrangement, the compositions and mode of action of the following: [i] r.f variable tuned amplifier, [ii] demodulator and [iii] a.f amplifier feeding loudspeaker. 6.4 Describe some of the limitations of the straight radio receiver such as: [i] ganging multiple r.f. signals	Lecture with the aid of a diagram: [i] Straight radio receiver [ii] circuit arrangement of (a) r.f. variable – tunned amplifier. (b) demodulator (c) a.f. amplifier feeding loud speakers. Lecture and solve	Lecture notes, reference texts and materials. -do-			Instruct the students to draw a labeled block diagram of a straight radio receiver explaining each stage of the receiver. Ask the students to explain, with the aid of simple circuit arrangement, the compositions and mode of action of the following: [i] r.f variable tuned amplifier, [ii] demodulator and [iii] a.f amplifier feeding loudspeaker.

	[ii] selectivity and [iii] Bandwidth requirement. 6.5 Explain, with the aid of a block diagram the working principle of super heterodyne radio receiver. 6.6 Explain the choice of intermediate frequency (i.f.). 6.7 Describe the characteristics and circuit arrangement of: [i] i f. amplifier and [ii] a local oscillator. 6.8 Explain the problem of second channel (image) interference.	problems. Explain the disadvantages of straight radio receiver. Discuss with the aid of a diagram: [i] the working principle of superheterodyne radio receiver and [ii] i.f amplifier and an oscillator circuitry.				Direct the students to explain the choice of intermediate frequency (i.f.), describe the characteristics, and circuit arrangement of: [i] i.f. amplifier and [ii] a local oscillator.

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Computational Physics	**Code:** PYE 414	**Contact Hour:** 1 Hours/week
Credit unit: 1 Unit	**Pre-requisite:**	**Theoretical:** 1 Hours/week
Year: 2	**Semester:** First	**Practical:** 0 Hours/week

Course main Goal: This course is designed to enable student develop skill to apply numerical analysis to solve problems or support theories in Physics/Electronics.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apply error analysis and numerical integration in data analysis
2.0 Appreciate Deterministic randomness, interpolation and extrapolation of a given variable
3.0 Apply Monte Carlo methods in solving transfer equations problems
4.0 Apply Root finding methods in solving complex equations problems
5.0 Appreciate derivatives using finite difference method
6.0 Recognize system of linear equation and commercial subroutine libraries
7.0 Apply ordinary differential equations and partial differential equation in solution to variable systems
8.0 Apply hyperbolic equations and conservative methods in solving problems in systems
9.0 Apply Fourier transform in predicting stability of systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Computational Physics		**Code:** PYE 414		**Credit Units:** 1 Unit		
Course specifications: Theoretical contents		**Practical Code:** None		**Contact Hours:** 1 Hours/Week		
General Objective 1.0 Apply error analysis and numerical integration in data analysis						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	Define error and precision. 1.1 Explain the relationship	Explain methods of error combination of dependent and	Textbook Lab-manual			Direct the students to explain the applications of

	between error and precision 1.2 Explain methods of combination of errors 1.3 Explain stability in Computational Physics 1.4 Explain the following methods of numerical integration [i] Trapezoidal [ii] Simpson [iii] Bode rules [iv] Open and semi-open formulae and [v] Gaussian quadrature.	independent quantities Explain the trapezoid and Simpson's rule				Simpson's rule in solving buoyancy and stability problems when designing marine vessel.
General Objectives 2.0 Appreciate deterministic randomness, interpolation and extrapolation						
	2.1 Describe Random Error generators. 2.2 Explain the following forms of Deterministic Randomness: [i] linear congruent method [ii] Random walk [iii] non uniform distribution of random numbers [iv] Gussian and arbitrary distribution [v] Von Neumann rejection method 2.3 Define interpolation and extrapolation. 2.4 Define the Newton-Gregory forward difference interpolation formula 2.5 Evaluate data using [i] polynomial interpolation [ii] Neville's algorithm [iii] cubic spine [iv] data fitting and [v]	Illustrate the differences in extrapolation and interpolation. Explain Von Neumann rejection technique in sampling. Define the Newton-Gregory forward difference interpolation formula and evaluate data using [i] polynomial interpolation [ii] Neville's algorithm [iii] cubic spline [iv] data fitting and [v] least	Lecture notes and reference texts. -do-			Ask students to explain the purpose of Rejection sampling and evaluate a table using Lagrange interpolation formula. Instruct the students to define the Newton-Gregory forward difference interpolation formula and evaluate data using [i] polynomial interpolation [ii]

	least square fits.	square fits.				Neville's algorithm [iii] cubic spline [iv] data fitting and [v] least square fits.
General Objectives 3.0 Apply Monte Carlo methods in solving transfer equations problems						
	3.1 Define Monte Carlo Simulation 3.2 What are the areas of application of the Monte Carlo Simulation? 3.3 Explain the following; [i] integration by rejection and [ii] integration by importance sampling Integration by Von Neumann rejection	Solve problems involving integration by rejection Illustrate the area of application of Monte Carlo simulation	Lecture notes, reference texts and materials.			Direct the students to explain Monte Carlo simulation Explain how Monte Carlo simulation provides an efficient way to simulate processes involving chance and uncertainty
General Objectives 4.0 Apply root finding methods in solving complex equations problems						
	4.1 Apply root finding and equation solving in: [i] bracketing [ii] Bisection [iii] Secant [iv] false position and [v] Newton Raphson methods in computational physics	Apply Newton-Ralphson iteration formula to nonlinear equations	Lecture notes, reference texts and materials.			Direct students to derive the root of the equation:- $\cos x = x^2$ as accurately as your tables permit.
General Objective 5.0 Appreciate derivatives using finite difference method						
	5.1 Apply grid method for classical and quantum fields in: finite difference method finite volume method quantum wave equation	Apply the forward, backward and central difference formula in solving related practical problems	Textbook Lab-manual		Demonstration	Ask students to briefly explain the forward differencing method.
General Objectives 6.0 Recognize system of linear equation and commercial subroutine libraries						
	6.0 Define linear equation. 6.1 Solve linear equation problems	Solve linear algebraic equations using Gaus-	Lecture notes,			Ask students to derive the solution

	using Gauss- Jordan elimination, $\underline{\boldsymbol{L-U}}$ decomposition and Eigen problems. 6.2 Define commercial subroutine libraries 6.3 Explain the principles of code optimization in commercial subroutine libraries	Serdel interaction methods Explain developments in commercial subroutine libraries.	reference texts and materials.			to a linear equation using Gauss-Jordan elimination method. Direct students to list out notable numerical libraries used in software development for performing numerical calculations.
General Objectives 7.0 Apply ordinary differential equations and partial differential equation and applications						
	7.1 Identify first and second order ordinary differential equation. 7.2 Identify first and second order partial differential equation. 7.3 Explain the techniques of solving first and second order Ordinary differential equation using [i] Euler method,[ii] Runge- Kutta method, [iii] boundary condition, [iv] Numerov's method, [v] adaptive stepsize control, [vi] Bulirshc-Stoer methods and [vii] order reduction 7.4 Explain the techniques of solving [i] first and second order partial differential equation [ii] finite elimination method and finite volume	Apply the Laplacian concept in polar coordinates to partial differential equation problem Demonstrate method of solving first and second order differential equation using Runge-Kutta and Euler methods Explain the techniques of solving [i] first and second order partial differential equation [ii] finite elimination	Lecture notes, reference texts and materials. -do-			Direct the students to apply ordinary differential equation in calculating the flow of electricity and explaining thermodynamic concepts. Ask students to explain the application of partial differential equation in the mathematical formulation and aid the solution to

	method. 7.5 Apply differential equation in solving problems of [i] nonlinear oscillators, and [ii] Schrodinger equations. 7.6 Classify partial differential equation into [i] hyperbolic equation, [ii] parabolic equation and [iii] elliptic equation. 7.7 Use parabolic equation to solve diffusion problems	method and finite volume method and apply differential equation in solving problems of [i] nonlinear oscillators, and [ii] Schrodinger equations.				physical problems involving several variables such as propagation of heat and sound.
General Objectives 8.0 Apply hyperbolic equations and conservative methods in solving problems in systems						
	8.1 Define hyperbolic and flux conservative method. 8.2 Solve problems in hyperbolic and Flux conservative equations using:- Von Neumann stability analysis Courant-Friederichs-Lewy condition Euler (FTCS) method Staggered Leapfrog method Lax method Two step lanxWendroff method etc 8.3 Compare Relaxation vs Rapid method in solving Elliptic equation.	Explain these methods of solving elliptic equation:- Gauss Seidel method *Jacobi method *Successive over relaxation method	Lecture notes, reference texts and materials.			Direct students to explain the use of hyperbolic functions to describe the shape of the curve formed by high voltage line suspended between two towers.
General Objective 9.0 Apply Fourier transform in predicting stability of systems						
	9.1 Define Fourier series 9.2 Explain periodic functions 9.3 Evaluate the integration of Fourier series	Derive the Fourier coefficient in both polar and rectangular forms	Lecture notes, reference texts and			Direct student to show how Fourier transform may be applied in image

	9.4 Apply Fourier series to suitable engineering problems.		materials.			analysis, image filtering and reconstruction

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Digital Electronics	**Code:** PYE 415	**Contact Hour:** 4 Hours/week
Credit unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: this course is designed to enable students acquire requisite knowledge on digital electronic circuits

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apply basic knowledge of the concept of digital systems
2.0 Appreciate the number systems and their operations
3.0 Appreciate Boolean algebra and its simplification
4.0 Develop combinational circuits and operate them with logic gates
5.0 Apprehend requisite knowledge on flip-flop and digital counters
6.0 Apply shift registers for storage of data in digital circuits
7.0 Apply signal interfacing, processing and decoding in digital systems
8.0 Apprehend knowledge on integrated circuits technology

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Digital Electronics			**Code:** PYE 415		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 418		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Apply the basic knowledge of the concept of digital systems						
Week		**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Define the two broad areas of electronic circuits 1.2 Define analogue and digital electronics 1.3 Use graphs to illustrate the difference between digital and analogue quantities 1.4 State the advantages of digital systems over analogue systems 1.5 Give examples of digital systems 1.6 Define bit as used in a binary system 1.7 Explain how voltage levels are used to represent bits in digital circuits 1.8 Describe the characteristics of a digital waveform 1.9 Explain timing diagrams and State	Lecture and illustrate differences between digital and analogue circuits using relevant diagrams and available materials Show waveforms that are analogue and those that are digital in nature	Lecture notes and available instruments Signal generator and an oscilloscope	Identify different types of analogue and digital instruments used in our day-to-day activities Display both analogue and digital signals and measure their voltage levels	Guide student in the identification of types of analogue and digital instruments Guide student towards the measurement of voltage levels	Ask the students to explain with examples a system that is analogue in nature and one that is a combination of both analogue and digital. Direct students to describe the characteristics of a digital waveform

	their purpose in digital electronics of 1.9 1.10 Distinguish between serial and parallel data transfer 1.11 State the advantages and disadvantages of each of the methods in 1.10 1.12 Identify the three basic logic operators 1.13 Illustrate the operation of each of the identified operators with suitable diagrams	Draw waveforms to illustrate the timing diagrams Enumerate the basic operator and show modules of each	Textbooks and classroom resources Logic modules for NOT, AND, and NOR operators	Apply voltage levels for HIGH and LOW inputs to the basic operators and obtain information about the behaviours of each of their outputs	Guide students to connect relevant circuits for testing the behaviours of the basic operators with combinational inputs	Instruct the students to distinguish between serial and parallel data transfer and to state the advantages and disadvantages of each of the methods in 1.10. Ask students to explain the 3 basic logic operators
General Objectives 2.0 Appreciate the number systems and their operations						
	2.1. Explain why the decimal system is a weighted system 2.2. Explain how powers of ten are used in the decimal system 2.3. Determine the weight of each digit in a decimal number 2.4. Define binary number 2.5. Convert binary	write the digits in a decimal system and use some examples of decimal numbers to determine their weights write different binary and decimal numbers and convert the binary ones to decimal	Lecture notes, reference texts and materials. Lecture notes and textbooks			Direct the students to list some decimal numbers and determine their weights

	number to decimal numbers and vice versa 2.6. Draw tables to illustrate the maximum bits in each of the number systems of binary, octal and hexadecimal 2.7. Carry out addition, subtraction, multiplication and division in each of the number systems 2.8. Define the 1's and 2's complements 2.9. Convert binary numbers to their 1's and 2's complements 2.10. Explain the applications of 1's and 2's complements in a computer system 2.11. Define binary coded decimal (BCD) 2.12. Express some decimal numbers in BCD and vice versa 2.13 Identify other codes that are used in digital	and decimal to binary implement the conversion from these number system to decimal and vice versa use examples from textbooks to carry out these arithmetic operations Use examples to carry out these conversions processes give examples of 1's and 2's complements and show student how	Lecture notes, reference texts and materials.			Ask the students to give examples of each number system and convert them to decimal numbers. Ask the students to work out exercises given in this topic

	systems and explain how they are applied	to do the conversion	Textbooks and classroom resources			
General Objectives 3.0 Appreciate Boolean algebra and its simplification						
	3.1. Define Boolean algebra 3.2. Apply the basic laws and rules of Boolean algebra to simplify logic expressions 3.3. Simplify logic expressions using De-Morgan's theorems 3.4. Convert logic expressions to sum-of-product and product-of-sum forms 3.5. Define a Karnaugh map to simplify logic expressions of two three and four variables 3.6. Use Karnaugh map to simplify logic expressions of two, three and four variables	Apply the relevant laws to prove the validity of the Boolean rules Define a Karnaugh map to simplify logic expressions of two three and four variables and use Karnaugh map to simplify logic expressions of two, three and four variables Draw tables of cells to illustrate the application of the two, three and four variable expressions	Lecture notes, reference texts and materials. Lecture notes, reference texts and materials.			Ask students to compose different logic statements and express them in Boolean form Direct the students to define a Karnaugh map to simplify logic expressions of two three and four variables and use Karnaugh map to simplify logic expressions of two, three and four variables Instruct the students to give examples

						of logic expressions and simplify them using Karnaugh map
General Objectives 4.0 Develop combinational circuits and operate them with logic gates						
	4.1 Define logic gate and truth table 4.2 Differentiate logic gates using their symbols and produce corresponding truth tables to implement them. 4.3 Construct different combinational circuits and obtain their corresponding outputs with combination of inputs 4.4 Obtain different logic/Boolean expressions and simplify them using Boolean rules, truth tables and Karnaugh map 4.5 Implement the outcomes of the simplified expressions in 4.4 using suitable logic gates	Explain the operations of the logic gates with illustrative diagrams Explain the construction circuits and show the logical means of obtaining their outputs Illustrate with examples the methods used in the simplification of logic/Boolean expressions	Textbooks Logic modules and multism Textbooks Logic gates/modules and multism. Lecture notes, reference texts and materials.	Construct logic circuits using logic gates/modules and determine their output experimentally	Guide the students in the construction of logic circuits	Direct the students to define logic gate and truth table and draw the different logic gates using their symbols and produce corresponding truth tables to implement them Ask the students to explain what makes a circuit to be combinational Direct the students to explain minimization

						as applied to logic expressions
General Objectives 5.0 Apprehend requisite knowledge on flip-flop and digital counters						
	5.1 Define a flip-flop 5.2 Distinguish a flip-flop from a latch 5.3 Identify the operations of the different types of flip-flops with suitable diagrams 5.4 Define non-stable and a stable multivibrators. 5.5 Explain the operations in 5.4 above using suitable diagrams 5.6 Define digital counters 5.7 Distinguish between asynchronous and synchronous counters 5.8 Describe the operations of different types of synchronous and asynchronous counters 5.9 Explain the methods for designing digital counters	Draw the symbols for the different types of flip-flops and explain their operations Draw the symbols for multivibrators and explain their operations Draw the circuits for the different types of counters and describe their operations Show how to design a digital counter illustrating	Lecture notes, reference texts and materials. Logic modules ICs and data book Textbooks and classroom resurces Textbooks Logic modules ICs and data books Textbook Digital modules	Experiment with multism or available digital modules to illustrate the operations of flip-flop Experiment with the designed counter to confirm workability of the method	Guide the students towards the construction of flip-flop circuits Guide the students in the design of counters	Ask students to explain what is the other name for flip-flop Direct the students to define digital counters, distinguish between asynchronous and synchronous counters. List and describe the

	5.10 Describe how counters can be cascaded for various applications 5.11 Enumerate the various applications of counters	with an example and implement the outcome using logic gates	Data book and multism			operations of different types of synchronous and asynchronous counters
General Objectives 6.0 Apply shift registers for storage of data in digital circuits						
	6.1 Define shift register and storage capacity 6.2 Illustrate with a diagram of a flip-flop the mode by which data is stored 6.3 Explain how the different types of shift register operate (e.g. SISO, SIPO, PISO, PIPO and Bidirectional types) 6.4 Explain the operation of shift register counter 6.5 Highlight some of the applications of shift registers	Draw diagrams to explain the operations of shift register Draw a circuit of the counter and describe its operations	Textbooks Logic ICs, Logic module and data book Lecture notes, reference texts and materials.	Construct the different shift registers and observe their operations	Guide students in the construction of shift registers	Ask the student to draw timing diagrams to describe the operation of each shift register and counter
General Objectives 7.0 Apply signal interfacing, processing and decoding in digital systems						
	7.1 Explain quantization and sample-and-hold operation as applied to signal conversion 7.2 Different types of analogue-to-digital and digital-to-	Draw necessary diagrams to explain terms in 7.1 and describe the operations of converters listed in 7.2	Textbooks Digital ICs and data book	Carry out experiments to show the operation of the converters	Guide the students to construct the required circuits for the operations of the converters	Direct the students to explain why a converter is required in a digital circuit.

	analogue converters and describe the operation of each of them 7.3 Define decoder 7.4 Describe the operation of a 4-bit decoder 7.5 Distinguish between a decoder and an encoder 7.6 Highlight some applications of decoders and encoders in digital circuits	Draw the diagram of a 4-bit decoder and describe its operation Explain the function of a decoder and that of an encoder and state some of their applications	Textbooks Digital ICs and data book Textbooks and data book			Direct students to mention some applications of decoders and encoder apart from those earlier listed.
General Objectives 8.0 Apprehend knowledge on integrated circuits technology						
	8.1 Highlight some of the characteristics of digital ICs 8.2 Identify the various configurations for the digital ICs in the logic family and explain their pin connections 8.3 State some of the precautions to be taken while using digital ICs 8.4 Mention some areas of applications of the digital ICs	Explain some of these characteristics Show some of these digital ICs to the students and give them for identification Mention some of these precautions and areas of applications	Lecture notes, reference texts and materials. Digital IC data Book and some test instruments	Identify some of the available digital ICs and state their pin connections	Guide students in the identification of these digital ICs	Ask students to distinguish a digital IC from an analogue device

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
COURSE TITLE: Applied Solar Energy	**Code:** PYE 416	**Contact Hours:** 4 Hours/week
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** First	**Practical:** 2 Hours/week

Course main Goal: this course is designed to introduce students to the fundamentals of solar energy conversion systems, available solar energy and local and national needs, photovoltaic and solar thermal engineering applications, and emerging technologies.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate the conversion of solar radiation to energy
2.0 Use measurement of geometry in calculations of solar radiation
3.0 Appreciate solar thermal and electrical energy conversions
4.0 Use control and drives for solar systems
5.0 Recognize the various solar collectors, performance and applications
6.0 Analyze the design and performance of solar photovoltaic systems
7.0 Appreciate the concept of design of solar energy system

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Applied Solar Energy			**Code:** PYE 416		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 418		**Contact Hours:** 2 Hours/Week	
General Objective: 1.0 Appreciate the conversion of solar radiation to energy						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Explain the world energy resources – Nigerian energy scenario. 1.2 Explain the	Explain basic laws of radiation Lecture to explain	Lecture notes, reference texts and materials.			Ask students to explain renewable energy resources and their

	environmental aspects of energy utilization. 1.3 Explain renewable energy resources and their importance 1.4 Describe global solar resources with reference to the Nigerian situation. 1.5 Explain solar spectrum and the electromagnetic spectrum. 1.6 State basic laws of radiation. 1.7 Explain the physics of the sun: energy balance of the earth. 1.8 Explain energy flux, 1.9 Explain solar constant for earth. 1.10 Explain greenhouse effect.	the global solar resources with reference to the Nigerian situation. Explain the physics of the sun: energy balance of the earth.	-do-			importance Give assignment to distinguish between solar spectrum and electromagnetic spectrum.
General Objectives 2.0 Use measurement of geometry in calculations of solar radiation						
	2.1 Explain solar radiation on the earth surface. 2.2 Explain terrestrial and extraterrestrial radiation and its characteristics. 2.3 Explain solar insolation. 2.4 Describe spectral energy distribution of solar radiation. 2.5 Explain depletion of solar radiation [i] absorption, [ii] scattering.	Lecture to Explain solar radiation on the earth surface. Explain terrestrial and extraterrestrial radiation and its characteristics.	10 Solar cells, 1 resistor 22 Ω, 2 multimeter, 1 bulb, 4 LED lights, 1 rule, 1 thermometer, Luxmeter 10 Solar cells, 1 resistor 22 Ω, 2	Determine the effects of different heights on solar cell Determine the	Direct the students to determine the effects of different heights on solar Instruct the	Direct the students to explain solar radiation on the earth surface. Ask the student to distinguish

	2.6 Explain beam radiation, diffuse and global radiation. 2.7 Explain the measurement of solar radiation [i] pyranometer, [ii] pyrheliometer, and [iii] sunshine recorder. 2.8 Explain [i] solar time - local apparent time (LAT) and [ii] equation of time (E). 2.9 Explain solar radiation geometry [i] Earth-Sun angles and [ii] solar angles. 2.10 Explain the calculation of angle of [i] incidence, [ii] surface facing due south, [iii] horizontal, inclined surface and [iv] vertical surface. 2.11 Explain [i] solar day length [ii] Sun path diagram and [iii] shadow determination. Estimation of sunshine hours at different places in Nigeria. 2.12 Calculation of total solar radiation on horizontal and tilted surfaces. 2.13 Prediction of solar radiation availability.	Explain the instrument used for the measurement of solar radiation pyranometer, pyrheliometer, and sunshine recorder. Explain the derivation of angle of [i] incidence, [ii] surface facing due south, [iii] horizontal, inclined surface and [iv] vertical surface. Explain solar radiation geometry Explain the Estimation of sunshine hours at different places in Nigeria.	multimeter, 1 bulb, 4 LED lights, 1 rule, 1 thermometer, Luxmeter 10 Solar cells, 1 resistor 22 Ω, 2 multimeter, 1 bulb, 4 LED lights, 1 rule, 1 thermometer, Luxmeter Lecture notes, reference texts and materials.	effect of different angle on the power of a solar cell Determination of the effect of light source with different wavelength	students to determine the effect of different angle on the power of a solar cell Direct the students to determine the effect of light source with different wavelength	between terrestrial and extraterrestrial radiation and its characteristics. Give assignment to explain the instruments used for the measurement of solar radiation pyranometer, pyrheliometer, and sunshine recorder. Ask the students to explain the derivation of angle of [i] incidence, [ii] surface facing due south, [iii] horizontal, inclined surface and [iv] vertical surface. Ask students to

						explain solar radiation geometry and estimate sunshine hours at different places in Nigeria
General Objectives 3.0 Appreciate solar thermal and electrical energy conversions						
	3.1 Explain thermodynamic cycles [i] Carnot [ii] Organic, [iii] reheat, [iv] regeneration and [v] supercritical Rankine cycles [vi] Brayton cycle [vii] Stirling cycle [viii] Binary cycles [ix] Combined cycles. 3.2 Explain solar thermal power plants: parabolic trough system. 3.3 Explain [i] hybrid solar-gas power plants, [ii] solar pond based electric-power plant, [iii] central tower receiver power plant. 3.4 Explain solar photovoltaic energy and its conversion principles - Physics and operation of solar cells. 3.5 Explain classification of solar PV systems. 3.6 Describe Solar cell energy conversion efficiency, [i] I-V characteristics, effect of variation of solar	Explain thermodynamic cycles Explain the following solar plant: solar thermal power plants, hybrid solar-gas power plants, solar pond based electric-power plant, and central tower receiver power plant Explain solar photovoltaic energy and its conversion principles. Explain the classification of solar PV systems.	Tamiya solar panel - single solar cell with stand, small screw driver, 2 alligator clips, large protractor, colored filters – red, blue, green, and yellow, voltmeter, 100 led light string, ruler, cardboard, LED apparatus.	Determine the effects of light intensity, wavelength, shading, and angle of incidence on the efficiency of a solar cell.	Direct the students to determine the effects of light intensity, wavelength, shading, and angle of incidence on the efficiency of a solar cell.	Direct students to explain solar photovoltaic energy and its conversion principles Ask students to explain solar photovoltaic energy, its conversion

	insolation and temperature, [ii] losses. 3.7 Explain solar PV power plants. 3.8 Explain thermodynamic cycles [i] Carnot [ii] Organic, [iii] reheat, [iv] regeneration and [v] supercritical Rankine cycles [vi] Brayton cycle [vii] Stirling cycle [viii] Binary cycles [ix] Combined cycles. 3.9 Explain solar thermal power plants: parabolic trough system. 3.10 Explain [i] hybrid solar-gas power plants, [ii] solar pond based electric-power plant, [iii] central tower receiver power plant. 3.11 Describe solar photovoltaic energy and its conversion principles - Physics and operation of solar cells. 3.12 Explain classification of solar PV systems. 3.13 Explain Solar cell energy conversion efficiency, [i] I-V characteristics, effect of variation of solar insolation and temperature, [ii] losses.	Explain thermodynamic cycles Explain the following solar plant: solar thermal power plants, hybrid solar-gas power plants, solar pond based electric-power plant, and central tower receiver power plant Explain solar photovoltaic energy and its conversion principles. Explain the	Tamiya solar panel - single solar cell with stand, small screw driver, 2 alligator clips, large protractor, colored filters – red, blue, green, and yellow, voltmeter, 100 led light string, ruler, cardboard, apparatus. Lecture notes, reference texts and materials.	Determine the effects of light intensity, wavelength, shading, and angle of incidence on the efficiency of a solar cell.	Direct the students to determine the effects of light intensity, wavelength, shading, and angle of incidence on the efficiency of a solar cell.	principles and solar cell energy conversion efficiency. Ask students to explain thermodynamic cycles [i] Carnot [ii] Organic, [iii] reheat, [iv] regeneration and [v] supercritical Rankine cycles [vi] Brayton cycle [vii] Stirling cycle [viii] Binary cycles [ix] Combined cycles. Direct student to explain solar photovoltaic energy, its conversion principles and operation of solar cells.

	3.14 Explain solar PV power plants.	classification of solar PV systems.				Give assignment on classification of solar PV systems
General Objectives 4.0 Use control and drives for solar systems						
	4.1 Explain the basic concepts of process control, discontinuous and continuous mode operation. 4.2 Explain introduction to proportional, integral and derivative control. 4.3 Explain controller design, characteristics and feedback compensation. 4.4 Describe response of controllers. 4.5 Explain Pneumatic and electronic realization of controllers. 4.6 Explain Selection of controllers, need for process controller, controller tuning and evaluation criteria. 4.7 Explain P/I and I/P converters. 4.8 Explain embedded systems [i] design cycle and [ii] 8051 microcontroller	Explain the basic concepts of process control, discontinuous and continuous mode operation. Explain embedded systems and response of controllers. Explain Pneumatic and electronic realization of controllers, Selection of controllers and the need for process controller, controller tuning and evaluation criteria. Explain P/I and I/P converters and embedded systems [i] design cycle and	ETAP Solar Field Design Software, Field Evaluation Sheet - Sample plot of land that includes the following: - GPS coordinates indicating the location of the field - A scale to measure the area of the field - Size of solar panels to be used and their optimum power production - Slope of land	Design of a solar field	Direct the students to design a solar field	Direct students to explain the basic concepts of process control, discontinuous and continuous mode operation. Ask students to explain P/I and I/P converters and embedded systems [i] design cycle and [ii] 8051 microcontroller requirement, challenges, trends and issues

	requirement, challenges, trends and issues. 4.9 Explain the use of emulator and in-circuit emulator. 4.10 State the applications of embedded system in control system and automation, handheld computer, IVR system and GPS receivers. 4.11 Explain basic and advanced control of solar plants- basic control algorithms, adaptive and optimal controls. 4.12 Describe the model based predictive control strategies, frequency domain control and robust optimal control.	[ii] 8051 microcontroller requirement, challenges, trends and issues. Explain the model based predictive control strategies, frequency domain control and robust optimal control.	Lecture notes, reference texts and materials.			Ask the student to explain basic and advanced control of solar plants- basic control algorithms, adaptive and optimal controls.
General Objectives 5.0 Recognize the various solar collectors, performance and applications						
	5.1 Explain the fundamentals of solar collectors as devices to convert solar energy to heat. 5.2 Describe non-concentrating low temperature flat-plate and evacuated tube collectors. 5.3 Explain optimal collector tilt and orientation. 5.4 Explain [i] collector	Lecture on the fundamentals of solar collectors as devices to convert solar energy to heat. Explain the process of concentration of collectors for middle and high temperature	Lecture notes, reference texts and materials.			Direct the students to explain the fundamentals of solar collectors as devices to convert solar energy to heat and the process of concentration of collectors for middle and high

	performance [ii] useful energy gain, [iii] energy losses, and [iv] efficiency. 5.5 Explain the use of selective coatings to enhance the collector efficiency. 5.6 Describe how to concentrate collectors for middle and high temperature applications. 5.7 Explain Line-focusing and point-focusing concentrators: parabolic trough, parabolic dish, heliostat field with central receiver, Fresnel lenses, compound parabolic concentrator, and sun tracking mechanisms. 5.8 Explain concentrating collector performance - concentration ratio, useful energy gain, energy losses, efficiency. 5.9 Describe solar collector design, testing, installation and operation. 5.10 State the application of non-concentrating collectors in low temperature solar thermal plants for space heating and cooling, drying,	applications. Explain Line-focusing and point-focusing concentrators: parabolic trough, parabolic dish, heliostat field with central receiver, Fresnel lenses, compound parabolic concentrator. Sun tracking mechanisms and solar collector design, testing, installation and operation. State the application of non-concentrating Solar collector. Explain solar collector design, testing, installation and operation and state the application of non-concentrating collectors in low temperature solar thermal plants for	Solar cell, variable resistor, digital multimeter (DMM), electric motor desk lamp, protractor, Vernier caliper Lecture notes, reference texts and materials.	Explore solar cells as renewable energy sources and test their efficiency in converting solar radiation to electrical power.	Direct the student to explore solar cells as renewable energy sources and test their efficiency in converting solar radiation to electrical power.	temperature applications. Ask the students to explain Line-focusing and point-focusing concentrators: parabolic trough, parabolic dish, heliostat field with central receiver, Fresnel lenses, compound parabolic concentrator and sun tracking mechanism. Ask the students to explain solar collector design, testing, installation and operation and state the

	seawater desalination. 5.11 Explain the use of concentrating collectors for process heat production and power generation	space heating and cooling, drying, seawater desalination.				application of non-concentrating collectors in low temperature solar thermal plants for space heating and cooling, drying, seawater desalination.
General Objectives 6.0 Analyze the design and performance of solar photovoltaic systems						
	6.1 Explain photovoltaic effect - principle of direct solar energy conversion into electricity in a solar cell. 6.2 Explain Semiconductor properties, energy levels, basic equations. 6.3 Describe solar cell, p-n I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature. 6.4 Describe commercial solar cells - production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells, dye-sensitized,etc. 6.5 Describe the design of	Lecture by explaining photovoltaic effect - principle of direct solar energy conversion into electricity in a solar cell and Semiconductor properties, energy levels, basic equations. Explain the characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature. Explain	Solar cell, incandescent amp with power supply, potentiometer, optical filters, multimeters, optical bench and clamp, connecting wires Solar cell, incandescent amp with power supply, potentiometer, optical filters, multimeters, optical bench and clamp, connecting	Determination of I-V Characteristic of a solar cell illuminated by sun, at different frequencies Determination of I-V Characteristic of a solar cell illuminated by an incandescent lamp, at different frequencies	Direct the students to determine the I-V Characteristic of a solar cell illuminated by sun at different frequencies. Direct the students to determine the I-V Characteristic of a solar cell illuminated by an incandescent lamp at different frequencies	Direct the students to explain the classification of PV systems: [i] central power station system, [ii] distributed PV system, [iii] standalone PV system, [iv] grid interactive PV system, [v] small system for consumer applications, [vi] hybrid solar PV system, [vii] concentrator solar photovoltaic.

	solar PV systems and cost estimation. 6.6 State the classification of PV systems: [i] central power station system, [ii] distributed PV system, [iii] standalone PV system, [iv] grid interactive PV system, [v] small system for consumer applications, [vi] hybrid solar PV system, [vii] concentrator solar photovoltaic. 6.7 Explain the PV system components [i] arrays, [ii] inverters, [iii] batteries, [iii] charge controls, [iv] net power meters. 6.8 Explain PV array installation, operation, costs, reliability. 6.9 State the applications of PV systems.	Semiconductor properties, energy levels, basic equations. List out the characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature. List the classification of PV systems: central power station system, distributed PV system, standalone PV system, grid interactive PV system, small system for consumer applications, hybrid solar PV system, and concentrator solar photovoltaic.	wires. Solar battery, 4 cells, with cable and connectors, thermopile, moll type, universal measuring amplifier. rheostat, 330 Ohm , 1.0 A, ceramic lamp socket E27, filament lamp,220V/120 W, hot/cold air blower, 1800 W, meter scale, tripod base PHYWE, barrel base PHYWE, support rod PHYWE, square 250 mm, right angle clamp PHYWE, plate holder, universal clamp, bench	Determination of the characteristic curves of a solar cell	Direct the students to Determine of the characteristic curves of a solar cell	Instruct the students to explain commercial solar cells - production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium dieseline cells, dye-sensitized etc.

			clamp PHYWE, Glass pane, 150x100x4mm, digital multimeter, lab thermometer,-10 +100 °C, connecting cord, 32 A, 500 mm, red, connecting cord, 32 A, 500 mm, blue			
General Objectives 7.0 Appreciate the concept of design of solar energy system						
	7.1 Explain the design of solar thermal systems for water, space heating, cooling and power generation. 7.2 Explain f-Chart calculation method for sizing solar water and space heating systems. 7.3 Explain the design of non-focusing and focusing collectors. 7.4 Explain the Design aspects of solar thermal energy storage systems. 7.5 Explain the selection criteria of storage materials for [i] heating and [ii] cooling applications, [iii] selection of heat transfer fluid for	Illustrate the design of solar thermal systems for water, space heating, cooling and power generation. Explain the design of non-focusing and focusing collectors. Explain the design aspects of solar thermal energy storage systems and the selection criteria of storage materials	Lecture notes and reference texts.			Ask students to explain with relevant examples the design of solar thermal systems for water, space heating, cooling and power generation.

	heating and cooling applications. 7.6 Explain the design of photovoltaic off-grid and grid- connected power systems. 7.7 Explain the design of system components - PV modules, batteries, charge controllers, inverters, and auxiliaries. 7.8 Describe the performance analysis of a photovoltaic system. 7.9 Explain the use of software codes for design of solar thermal and photovoltaic systems. 7.10 Explain the performance analysis of various solar thermal systems, [i] PV system and evaluation of solar thermal energy storage system, [ii] selection of components and materials, [iii] estimation of economics. 7.11 Explain the use of software tools for design of solar thermal and photovoltaic systems.	for [i] heating and [ii] cooling applications, [iii] selection of heat transfer fluid for heating and cooling applications. Explain the design of LHTES for solar process	Lecture notes, reference texts and materials.			Ask the students to explain the design of system components - PV modules, batteries, charge controllers, inverters, and auxiliaries. Ask the students to explain the use of software tools for design of solar thermal and photovoltaic systems.

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
COURSE TITLE: Acoustics	**Code:** PYE 417	**Contact Hour:** 1 Hours/week
Credit unit: 1 Units	**Pre-requisite:**	**Theoretical:** 1 Hours/week
Year: 2	**Semester:** First	**Practical:** 0 Hours/week

Course main Goal: This course is designed to introduce students to an in-depth understanding of the science of acoustic wave propagation, give practical engineering applications and understanding of how noise is quantified, how it is produced, how to mathematically express acoustic wave propagation, etc.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate the fundamentals of acoustics and sound principles
2.0 Appreciate the acoustic principles in speech and hearing
3.0 Appreciate vibration and vibration control
4.0 Recognize acoustics analogies and transduction
5.0 Appreciate sound reproduction
6.0 Appreciate indoor (architectural) and outdoor acoustics
7.0 Recognize sound absorbers and sound insulations
8.0 Appreciate underwater acoustics

PROGRAMME: HIGHER NATIONAL DIPLOMA SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
COURSE TITLE: Acoustics			**Code:** PYE 417		**Credit Units:** 1 Units	
Course specifications: Theoretical contents			**Practical Code:** None		**Contact Hours:** 1 Hours/Week	
General Objective 1.0 Appreciate the fundamentals of acoustics and sound principles						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**

	1.1 Outline the origin of sound energy as vibrating object. 1.2 Explain the propagation of sound through a media 1.3 Explain the following terms in relation to sound wave propagation (i) pitch (ii) timbre (iii) quality. 1.4 Derive the sound energy equation. 1.5 Define (i) sound intensity (ii) bel (iii) decibel. 1.6 State the relationship between intensity and amplitude. 1.7 Explain the following properties of sound: (i) interference (ii) diffraction (iii) reflection (iv) refraction. 1.8 Explain Doppler's effects. 1.9 Differentiate between standing wave and traveling wave. 1.10 Define resonance. 1.11 Describe the concept of vibrating air-column in an enclosure. 1.12 Prove that fundamental frequency of an air-column increases with	Lecture Explain the concept of sound as a result of vibrating object. Discuss how sound travels in various media. Write out the derived sound energy equation. Relate intensity and amplitude of sound. Discuss these terms: refraction, reflection, diffraction, and interference. Explain standing and traveling waves. Describe resonance and its effects. Show mathematically the relationship	Lecture notes, reference texts and materials.			Ask students to explain sound waves and its mode of applications. Direct the students to relation sound wave propagation to pitch, timbre, and quality. Ask students to solve problems involving refraction, reflection, diffraction, and interference.

	temperature.	between air-column and temperature				
General Objectives 2 .0 Appreciate the acoustic principles in speech and hearing						
	2.1 Explain the mechanism of hearing 2.2 Explain the characteristics of hearing [i]threshold, [ii] sensitivity, [iii] loudness, [iv] pitch, masking, [v] and frequency weighting. 2.3 Explain articulation index. 2.4 Explain speech-interference level.	Lecture Explain the concept and principles of speech and hearing.	Lecture notes, reference texts and materials.			Ask the students to explain the mechanism of hearing and to outline the characteristics of hearing.
General Objectives 3.0 Appreciate vibration and vibration control.						
	3.1 Explain vibration system modeling. 3.2 Explain energy of vibration. 3.3 Explain [i] damped oscillation, and [ii] forced oscillation 3.4 Explain vibration control. 3.5 Explain damping and damping ratio,	Lecture Explain the concept of vibration system, energy of vibration, types of oscillation and vibration control. Solve numerical examples and give	Lecture notes, reference texts and materials.			Direct the students to explain damped and forced oscillation. Ask the students to explain

	3.6 Describe vibration measurement (accelerometer). 3.7 Explain vibration (transverse and longitudinal) in [i] strings, [ii] pipes, [ii] ducts, [iii] bars, [iv] membranes and [v] plates.	assignments.				transverse and longitudinal vibration in strings, pipes, ducts, bars, membranes and plates.
General Objectives 4.0 Recognize acoustics analogies and transduction						
	4.1 Explain electro-mechanical analogies, and electro-acoustic analogies. 4.2 Explain reciprocal and anti-reciprocal transducers. 4.3 Explain transmitter and loudspeakers (reciprocal source and anti-reciprocal source, types of loudspeakers, loudspeaker cabinets, woofers, subwoofers and tweeters). 4.4 Explain receivers or microphones (reciprocal receiver and anti-reciprocal receiver, microphone directivity and sensitivity, types of microphones, calibration of receivers).	Lecture Evaluate electro-mechanical analogies for various transducers and give assignments. Explain receivers or microphones (reciprocal receiver and anti-reciprocal receiver, microphone directivity and sensitivity, types of microphones, calibration of receivers).	Lecture notes, reference texts and materials.			Ask the students to differentiate between electro-mechanical analogies, and electro-acoustic analogies. Direct the students to explain reciprocal and anti-reciprocal transducers.

General Objectives 5.0 Appreciate sound reproduction						
	5.1 Trace the historical overview of sound production. 5.2 Explain magnetic recording. 5.3 Explain digital recording 5.4 Explain the concept of voice recognition. 5.5 Explain playback audio equipment. 5.6 Explain portable audio playback equipment (e.g. MP3, MP4). 5.7 Describe future of sound reproduction.	Lecture Explain the different forms of sound reproduction and their prospects.	Lecture notes, reference texts and materials.			
General Objectives 6.0 Recognize indoor (architectural) and outdoor acoustics						
	6.1 Explain sound production in enclosures 6.2 Explain growth and decay of sound field in a room. 6.3 Explain reverberation time (Sarbine's formula) and state reverberation effect. 6.4 State the factors affecting [i] reverberation, [ii] absorption. 6.5 Explain [i] reflection of	Lecture Explain sound production in outdoors and indoors.	Lecture notes, reference texts and materials.			Direct the students to explain how sound is produced outdoors and indoors. Explain growth and decay of sound field in a room.

	sound, [ii] absorption coefficient, 6.6 Explain direct and reverberant sound field (critical distance, room constant and room coefficients). 6.7 Explain acoustic energy density and directivity. 6.8 Describe acoustic factors in architectural design [i] room [ii] hall and [iii] auditoriums. 6.9 Explain outdoor acoustical gain and the influence of directional [i] microphones [ii] loudspeakers on system maximum gain. 6.10 Explain band shells and outdoors auditoriums.	Explain direct and reverberant sound field, acoustic energy density and directivity. Explain acoustic factors to be considered in architectural design of a room, hall and an auditorium.	-do-			Solve examples related to reflection, refraction and absorption of sound waves
General Objectives 7.0 Appreciate sound absorbers and sound insulators						
	7.1 Differentiate types of sound absorbers. 7.2 Explain sound transmission loss and transmission coefficients. 7.3 Explain [i] mass control case [ii] field incidence mass law. 7.4 State the effect of	Lecture with examples Explain the different types of sound absorbers.	Lecture notes, reference texts and materials.			Ask the students to outline the effect of frequencies on sound transmission through panels, coincidence effect, and

	frequencies on sound transmission through [i] panels [ii] coincidence effect [iii] critical frequency. 7.5 Describe [i] single leaf construction [ii] double leaf construction (or double-panel partition), 7.6 Describe flanking transmission. 7.7 Explain noise insulation (ratings and insulation requirements), 7.8 Explain noise reduction of a wall. 7.9 Explain sound pressure level at various distances from walls, enclosures. 7.10 Describe acoustic barriers	Explain noise insulation (ratings and insulation requirements), and noise reduction of a wall. Explain sound transmission and insulators	-do-			critical frequency. Direct the students to explain noise insulation with regards to ratings and insulation requirements.
General Objectives 8.0 Appreciate underwater acoustics						
	8.1 Explain the basic concepts of sound propagation in water. 8.2 Explain speed and velocity profiles in water. 8.3 Describe transmission loss, 8.4 Explain absorption and refraction, 8.5 Explain mixed layer in	Lecture Explain the concepts of underwater acoustics.	Lecture notes, reference texts and materials.			Explain sonar transducer, their properties, and state sonar equation. Direct the students to

	under water acoustics. 8.6 Explain deep sound channel and reliable acoustic path, 8.7 Describe surface interference, 8.8 Explain sonar transducer, their properties, and state sonar equation. 8.9 Describe noise and echo, 8.10 Explain reverberation level and bandwidth consideration. 8.11 Explain transmission loss model for normal mode propagation.	Explain deep sound channel and reliable acoustic path. Explain the difference between noise and echo.	-do-			explain transmission loss model for normal mode propagation. Give students assignment to distinguish between noise and echo.

HND II SEMESTER 2

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
COURSE TITLE: Control Systems	**Code:** PYE 421	**Credit Hour:** 3 Hours
Course unit: 2 Units	**Pre-requisite:**	**Theoretical:** 1 hours/week
Year: 2	**Semester:** Second	**Practical:** 1 hours/week

Course Main Goal: This course is designed to introduce the students to the fundamentals of systems theory with emphasis on control system design and analysis to provides foundational tools that will enable the student understands and engineer control systems in a variety of application domains including robotics, embedded systems, power systems, electrical and electronics circuits.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Appreciate the basic concept of control systems
2.0 Develop mathematical models of physical systems
3.0 Apply feedback in control systems
4.0 Apply stability concepts in control systems
5.0 Analyze time and frequency responses of control systems
6.0 Apprehend basic knowledge on automatic control systems

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Control Systems			**Code:** PYE 421		**Credit Units:** 2 Units	
Course specifications: Theoretical contents			**Practical Code:** PYE 424		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Appreciate the basic concept of control systems						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Define system and control system 1.2 Give the two broad	Write and explain the two classes of control system	Lecture notes, reference texts and materials.			Ask students to identify the various control

	classes of control system (Open and Closed) 1.3 Explain each of them using suitable block diagrams 1.4 Illustrate the operation of control systems under the two broad classes given in 1.1 1.5 Explain some of the terms that are used in control systems 1.6 Identify some of the areas of application of control system in our domestic life	Mention some known examples and describe how they operate Mention some domestic applications of control systems	Domestic items	Identification of the control mechanisms in some selected domestic items	Guide the students towards the identification of the control system mechanisms	system mechanism
General Objectives 2.0 Develop mathematical models of physical systems						
	2.1 Define mathematical model of a control system 2.2 Describe the different methods by which a control system model can be analyzed 2.3 Highlight some of the physical systems such as mechanical, electrical, pneumatic, hydraulic, thermal etc. that can be modeled for analysis for control systems 2.4 Identify the elements of each of the physical	Mention examples of methods used such as block diagram, mathematical equations, signal flow, graph, etc. in analyzing models in control systems Explain how systems are modeled in different forms with the aid of requisite diagrams	Lecture notes, reference texts and materials. Lecture notes, reference texts and materials.			Direct the student to write the mason's gain formula and identify its components.

	systems highlighted in 2.3. 2.5 Define transfer functions 2.6 Use requisite methods from those listed in 2.2 to analyze transfer function of some examples of systems modeled as mechanical, electrical, thermal etc. 2.7 Give practical examples of some of the models highlighted in 2.3.	Draw the appropriate diagram for the model of the system being analyzed and apply the relevant methods for the analysis of its transfer function				Ask the students to explain models as used in control system.
General Objectives 3.0: Apply feedback in control systems						
	3.1 Define feedback system 3.2 State the characteristics of feedback in a control system 3.3 Enumerate some of the effects of feedback in a control system 3.4 Explain regenerative feedback 3.5 Give examples of some devices that are used as feedback mechanisms in systems	Mention some of these characteristics and explain them Highlight some of these effects which are reduction of parameter variation control of system dynamics, control of disturbance, linearization of system, etc and how they are achieved with relevant diagrams Draw a diagram to illustrate the regenerative feedback	Lecture notes, reference texts and materials. -do-			Direct students to state and explain the characteristics of feedback in a control system Instruct the students to enumerate some of the effects of feedback in a control system and give examples of some devices that are used as feedback mechanisms in systems

		Mention examples of these devices such as tachometer				
General Objectives 4.0 Apply stability concepts in control systems						
	4.1 Define stability in control systems 4.2 Mention some of the conditions for stability in a system 4.3 Name the methods used to evaluate system stability and explain how they are applied 4.4 Write the characteristics equations for some control systems and evaluate their stability using the methods named in 4.3. 4.5 Enumerate the concepts of controllability 4.6 Observe ability in control system	Explain the conditions for stability of systems Give examples of some stability methods such as Routh-Hurwitz, Nyquist criterion, Root-Locus, Liapunov etc. Work out the stability of systems with certain given characteristics equations Explain the concepts and state how they occur in systems	Lecture notes, reference texts and materials.			Ask students to explain stability in control and outline the conditions for stability of systems Direct the students to mention some of the components that are used to attain stability in systems Ask the student to explain the maximum value for a stable system

General Objectives 5.0 Analyze time and frequency responses of control systems						
	5.1 Explain the significance of analyzing a control system in the time domain 5.2 Distinguish between transient and steady-state response of a system 5.3 Identify the standard test signals that are used for analysis of time response 5.4 Determine the time response for first and second order systems by applying each of the types of test signals 5.5 Describe how a frequency response of a system can be obtained 5.6 Use the equation of a unity feedback system having input $r(t) = \times Sin\ \omega t$ to show from the output that frequency response is independent of amplitude and phase of the input signal 5.7 Explain the significance of determining the bandwidth of a system. 5.8 Explain the Nyquist and Bode plots and how they	Enumerate the importance of evaluating the time response of a system. Give the meaning of each of the two terms List some of the test signals such as step, ramp and parabolic Draw some examples of first and second order system and analyze them Explain the procedure for determining the frequency response of a system Write the equation for input of a unity feedback input and obtain its output. Show a typical graph of a frequency response curve and show the students how to obtain the bandwidth of a	Lecture notes, reference texts and materials. Textbooks and test instruments Textbooks and test instrument	Construct some basic circuits and analyze their time response Apply these test signals to circuits constructed under 5.1 and analyze their time response Build some first and second order systems and analyze their time response	Guide the students towards the construction and analysis Show the students the modes of applying the test signals and obtaining the time responses Provide circuits that can be constructed for analysis Provide the procedure and guide the students to	Direct the student to give the equation for the time response of a system and identify its components Direct the students to identify the test instruments that can be used for analyzing the time response of systems Ask the student to explain the correlation between

	are obtained	system from it Give examples of equations of systems and derive the various value for plotting both		Construct circuits for a first and second order systems and determine their frequency responses	construct and determine the frequency responses of the circuits	frequency responses and time response Direct the students to describe the graph used for bode plot structured
General Objectives 6.0 Apprehend basic knowledge on automatic control systems and digital computer						
	6.1 Define a process as applied to an industry 6.2 Enumerate some of the industrial processes 6.3 Use examples of some process control systems to illustrate the industrial processes 6.4 Explain the functions of the components/elements of an ideal industrial process control system 6.5 Describe the various types of process control systems 6.6 Explain the behavior of an automatic control system 6.7 Identify the two basis for classifying automatic controller 6.8 Describe the types of controllers under each of	Give some of the examples of industrial process and explain how they result in production of items Draw a block diagram of an ideal process control system and explain the functions of each of the elements/components List the various types of process control systems and mention some of their examples to describe their modes of functioning Draw the block diagram of an automatic control system and explain how	Textbooks and samples of products in the market Textbooks and samples of elements used in industrial processes	Identify the processes involved in the production of some selected items Identification of some elements used in process control and state their areas of application	Guide the students in the selection and identification of the processes involved in their production Get some available items that can be used in process control system and guide students on their areas of application	Instruct the students to explain the variables that influence the performance of an industrial process Direct the students to mention some industries and identify some of their processes Ask the students to mention some of the benefits of a process control system

	the classes of automatic controller. 6.9 Identify the four levels of process control system	it functions List the two basis for the classification of automatic controllers and these are: [i] according to their control actions [ii] upon the actuating medium. Mention and draw the block diagram of all the types in each class and discuss them e.g. P, PI, PID etc. Indicate the four levels in the form of a triangle and discuss each of them	Textbooks and controller modules			Direct the students to distinguish between the various types of automatic controllers and explain the benefits of implementing a process control system.

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Microelectronic Systems	**Code:** PYE 422	**Contact Hours:** 4 Hours/week
Credit unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** Second	**Practical:** 2 Hours/week

Course main Goal: This course is designed to provide students with an understanding of the structure, functionalism, and concept of micro processing system.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Outline the function of a CPU and its relation with other components of a Microprocessor System with respect to the address, data and control buses.
2.0 Appreciate the use of address selection and enabling signals within a microprocessor system
3.0 Recognize the fetch executive sequence.
4.0 Identify the main classes of instruction within the instruction set of a microprocessor and understands their operations.
5.0 Trace the dynamic execution of a simple machine code programme
6.0 Outline the organization of the stack and its uses by sub routines
7.0 Apply the principles of interrupts
8.0 Appreciate classification, packaging of, and technologies used in integrated circuits in microprocessor-based system.
9.0 Appreciate classification and packaging of technologies used in integrated circuits in microprocessor
10.0 Outline bus board design system layout, bus loading and distributions relate to signal degradation.
11.0 Solve practically the problem of signal degradation

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Microelectronic Systems	**Code:** PYE 422	**Credit Units:** 2 Units
Course specifications: Theoretical contents	**Practical Code:** PYE 424	**Contact Hours:** 2 Hours/Week
General Objective 1.0 Outline the function of a CPU and its relation with other components of a Microprocessor System with respect to		

the address, data and control buses.						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Draw a microprocessor containing instruction register (IR) Programmed counter (PC) store address register, accumulator, arithmetic and logic unit (ALU), Status register, control and timing devices and explain the purpose of each. 1.2 Draw a block diagram of a typical microprocessor system including a microprocessor memory (RAM and ROM), input/output, address bus, data bus, and control bus. 1.3 Explain the purpose of each component in 1.2 and the need for both RAM and ROM in a system. 1.4 Draw a typical memory map for a small system.	Lecture with examples Explain the internal structure of a microprocessor. Explain the function of each unit of a microprocessor system. State the application of microprocessor in practical systems. Solve problems on microprocessor system.	8-Bits Microcontroller/ Microprocessor Kits (Arduino Kit is handy). Various sensor types, actuators and modules Breadboard Expansion Board, Power Supply (5V/3.3V) are the under listed. #1 LCD1602 Module visual output device #2 Power Supply Module #3 Servo Motor actuator #4 Stepper Motor actuator #5 Ultrasonic Sensor proximity sensor #6 Temperature and Humidity sensor Module #7 IR Receiver	Show students practically using projector how to setup IDEs for 8bits, 16bits and 32 bits' architecture. Introduce students to most common Assembler and Compiler; Editor for 8bits/16bits/32bits architecture microprocessor readily available in Nigeria markets (AVR/PIC/STM and 8051/52). Example of the features of the IDE developed in 1.1. Introduce students to the use of Multisim and/or Proteus Simulation Packages.	Explain the architecture of the microprocessor Familiarize the students with the resources as listed in column 4	Ask students to draw a block diagram of a typical microprocessor system indicating the subunits Explain the purpose of each subunit

			communication module #8 DuPont and 65 Jumper Wire for connection #9 Active and Passive Buzzer audio output device #10 Potentiometer sensor (input device) #12 digit 7-segment Display visual output device #13 Multi-coloured LEDs Visual output device #14 Photo-resistor Sensor #15 Thermistor Sensor			
General Objectives: 2.0 Appreciate the use of address selection and enabling signals within a microprocessor system						
	2.1 Explain the meaning of a tri-select/enable signal for control of the third states. 2.2 Explain that there is no logical conflict on the address bus since the microprocessor is	Discuss the use of address selection in a microprocessor system and explain the importance of address bus, control bus and data bus in a microprocessor	Lecture notes, reference texts and materials.	Solve examples by simulation using Proteus/Multsim and physical realisation using a typical microprocessor/microcontroller architecture.	Introduce the use of the software to students.	Direct the student to discuss the use of address selection in a microprocessor system and explain the importance of address bus, control bus and date bus in

	the only talker. 2.3 Deduce that the microprocessor, RAM, ROM and input devices can all act as talkers on the common data bus without conflict by the use of tri-state devices. 2.4 Explain the process of address decoding and examine manufacturer's literature on commercial clips. 2.5 Describe how part of the control bus (e.g. clock, read, write e.t.c) are used to control the data transfers. 2.6 Analyze schematic diagrams showing the interconnection of processing, memory and I/O ports using data address, read/write-enabling signals. 2.7 Examine the relationship between the signals in 2.6 using a CRO or logic	system. Explain the process of address decoding and examines manufacturer's literature on commercial clips. Analyze schematic diagrams showing the interconnection of processing, memory and I/O ports using data address, read/write-enabling signals and examine the relationship between the signals.	Lecture notes, reference texts and materials.	Introduce the student to microprocessor/microcontroller port initialisations. Write and develop application for blinking LEDs, right and left shifting data manipulation. Write and develop source code for serial port, parallel port, SPI, I2C and one-wire data transfer. Interface microcontroller/microprocessor to assorted sensors/modules using protocols in 2.3. Trace signals on communication lines (bus) using CRO.	Develop application for blinking LED	a microprocessor system. Direct students to Explain the process of address decoding and examine manufacturer's literature on commercial clips. Instruct the students to analyse the schematic diagrams showing the interconnection of processing, memory and I/O ports using data address, read/write-enabling signals and examine the relationship between the signals

	analyzer.					
General Objectives 3.0 Recognize the fetch executive sequence						
	3.1 Explain the basic operation as fetching the instruction to the microprocessor, decoding the instruction within the microprocessor, fetching more data required and executing the instruction. 3.2 Illustrate the fetch execute sequence for a simple data transfer instruction involving the accumulator and memory on I/O port. 3.3 Illustrate the execute sequence for a simple jump instruction. 3.4 Interpret timing diagrams to show the relationship between clock pulses and bus signals for the transfer defined in 3.2	Lecture with examples Explain the fetch cycle in a microprocessor. Give examples to students to illustrate the fetch execute cycle (sequence) Explain with the aid of suitable diagrams the synchronization of bus microprocessor system	Lecture notes, reference texts and materials. -do-	Introduce students to electronics components interfacing to microprocessor/microcontroller. Solve problems using signal conditioning. Signal processing: Analogue to Digital Conversion (ADC) and Digital to Analogue Conversion (DAC). Signal processing: simple approach digital signals filtering. Voltage level conversion for ADC processing. (0 -5V, -5V- 0 +5V, 0 – 12V and -15V –0 - +15V).	Conduct practical to interface electronic components to microprocessor	Ask the students to illustrate the execute sequence for simple jump instruction. Direct the students to solve problems using signal conditioning.
General Objectives 4.0 Identify the main classes of instruction within the instruction set of a microprocessor and understand their operations.						
	4.1 Give examples from main types of instruction groups:	Lecture with examples. Discuss the types of		Explain simple and basic interfacing techniques and solve	Conduct practicals to develop	Ask the students to explain the use of four address modes.

	data transfer instructions memory reference and 1/0, arithmetic and logic instructions test and branch instructions. 4.2 Explain the use of four addressing modes and differentials between them.	instruction set. Describe the features of the addressing modes in 4.2.	Lecture notes, reference texts and materials.	examples on control relay. Develop applications to control dc and ac loads at various power levels more than 1000W. Introduce concepts of Pulse Width Modulation (PWM) to the students. Solve typical applications of using PWM for; dimmer, DC/AC motor speed controller.	application to control AC and DC loads at various power levels	
General Objectives 5.0 Trace the dynamic executive of a simple machine code programme						
	5.1 Explains that, for any given problem, a set of steps, called an algorithm, must be created which will solve the problem. 5.2 Define the algorithm (draws the programs) to solve a given sample problem. 5.3 Define that in order to load and execute a simple program. Some software must already exist within	Lecture with examples Give assignment. Give examples of algorithm. Explain the importance of flow chart in writing programs. Give assignment on trace tables. Illustrate with suitable timing diagram the variation of bus	Lecture notes, reference texts and materials.	Show student PCB development for microprocessor/microcontroller application. Introduce students to basic rules in PCB designs for implementation of fast switching microprocessor/microcontroller system. Introduce student to	Introduce students to basic rules in PCB designs	Ask students to define the algorithm to solve a given sample problem Introduce students to basic rules in PCB designs for implementation of fast switching microprocessor/microcontroller system.

	the machine. 5.4 Construct trace tables of the problem in 5.2 5.5 Verify the trace table in 5.4 by loading and single. 5.6 Examine the bus signals under clock control during the execution of programs in 5.2	signals under clock control during the execution of programs.	-do-	signals resistance, inductance and capacitance. Solve PCB examples for applications in 2.4.		
General Objectives 6.0 Outline the organization of the stack and its uses by sub routines						
	6.1 Explain the mechanism of the stack as a last in first out (LIFO) store and the function of the stack pointer in this operation. 6.2 Explain the use of the stack in the storing of the return address from sub routine of a sub routine, saving of MPU resister contents. 6.3 Show how the stack can be used to pass parameters between the main program and a sub routine. 6.4 Test sub routine for: timing delay, a defined mathematical	Lecture with worked examples Explain the working principles of stack memory. Solve problems involving stack memory.	Lecture notes, reference texts and materials.			Direct the students to explain the mechanism of the microprocessor response upon receipt of an interrupt.

	function, an input or output routine.					
General Objectives 7.0 Outline the principles of interrupts						
	7.1 Deduce why interrupts are necessary especially in the handling of data transfer between peripheral and computer. 7.2 Explain how an interrupt may cause the main program to call an interrupt servicing an interrupt. 7.3 Infer that in returning from the ISR, the main program should continue as thought it had never been interrupted. 7.4 Explain the use of the stack in saving and restoring MPU registers when servicing an interrupt. 7.5 Explain the mechanism of the	Explain the principle of interrupt in data transfer. Explain the relationship between MPU registers, stack and interrupt. State the types of interrupts and their applications.	Lecture notes, reference texts and materials. -do-			Ask the students to explain the principle of interrupt in data transfer. Instruct the student to explain the use of the stack in saving and restoring MPU registers when servicing an interrupt.

	microprocessor response upon receipt of an interrupt. 7.6 Distinguish between maskable and non-maskable interrupts.					
General Objectives 8.0 Appreciate classification, packaging of, and technologies used in integrated circuits in microprocessor based system						
	8.1 Identify, using manufacturer's literature the characteristics of a single chip computing element e.g. 8 bit and 16 bit processors and bit slice elements. 8.2 Describe the use of manufacturer's literature, its function, operations and distinguishing characteristics of Static RAM, dynamic RAM, MOS, EPROM, EEROM and parallel output port. 8.3 Investigate practically the performance of these devices with reference to manufacturer's data	Explain characteristics, functions and operations of items in 8.1 and 8.2 using manufacturer's literature. Discuss the use of manufacturer's literature, its function, operation and distinguishing characteristics of static RAM, dynamic RAM, MOS, EPROM, EEROM and parallel output port.	Lecture notes, reference texts and materials. -do-			Direct the students to discuss the performance of the 16 bit processor Ask the students to explain the use of manufacturer's literature, its function, operation and distinguishing characteristics of static RAM, dynamic RAM, MOS, EPROM, EEROM and parallel output port.

	sheets and the system design.					
General Objectives 9.0 Appreciate classification and packaging of technologies used in integrated circuits in microprocessor						
	9.1 Write programs involving assignment, selection and iteration. 9.2 Execute the programs written in 9.1 9.3 Write language program to: parallel ports, serial ports involving the use of sub routines and interrupts	Illustrate with examples Guide the students to write, debug and create programs in assembly language.	8-Bits Microcontroller/ Microprocessor Kits (Arduino Kit is handy). Various sensor types, actuators and modules are: Breadboard Expansion Board, Power Supply (5V/3.3V) are the under listed. #1 LCD1602 Module visual output device #2 Power Supply Module #3 Servo Motor actuator #4 Stepper Motor actuator #5 Ultrasonic Sensor proximity sensor	Write, debug and create programs in assembly language	Conduct practicals to write, debug and create programs in assembly language	Direct the students to write programs involving assignment, selection and iteration
General Objectives: 10.0 Outline bus board design system layout, bus loading and distribution relate to signal degradation						
	10.1 Relate logic circuit diagrams to printed	Explain the sources of digital signal	Lecture notes, reference texts			Ask the students to explain the causes

	circuit board (P.C.B) layout. 10.2 Describe the effect inductance, capacitance and resistance associated with P.C.B's on high-speed digital signal.	degradation in printed circuit board	and materials.			of digital signal degradation in printed circuit board
General Objectives 11.0 Solve practically the problem of signal degradation						
	11.1 Use buffer elements to prevent ringing in bus lines. 11.2 Use decoupling networks to eliminate cross talk	Solve problems on signal degradation in PCB.	Lecture notes, reference texts and materials.			Direct the students to solve problems on signal degradation in PCB.

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)		
Course Title: Equipment Reliability.	**Code**: PYE 423	**Contact Hours:** 2 Hours
Credit Unit: 2 Units	**Pre-requisite:**	**Theoretical:** 2 Hours/week
Year: 2	**Semester:** Second	**Practical:** 0 Hours/week

Course main Goal: This course is designed to enable students know the basic concepts of reliability engineering and its importance in electronics equipment and systems.

General Objectives:

On the completion of the course, the student should be able to:

1.0 Apply the basic concepts of reliability
2.0 Recognize failure and failure rate
3.0 Appreciate the concept of reliability prediction
4.0 Outline the causes of component/equipment failure

5.0	Comprehend the concepts of maintainability and maintenance
6.0	Comprehend the concepts of specifications and testing methods

PROGRAMME: HIGHER NATIONAL DIPLOMA IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS)						
Course Title: Equipment Reliability			**Code:** PYE 423		**Credit Units: 2 Units**	
Course specifications: Theoretical contents			**Practical Code:** None		**Contact Hours:** 2 Hours/Week	
General Objective 1.0 Appreciate the basic concepts of reliability						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Evaluation**
	1.1 Explain the basic concept of equipment reliability. 1.2 Describe the need for reliability tool. 1.3 State the applications and benefits of reliability tool. 1.4 Explain the difference between quality and reliability. 1.5 State the difference between reliability and quality control. 1.6 Explain life - cycle conditions of products. 1.7 Explain reliability as a relative measure. 1.8 Explain probabilistic reliability, 1.9 Describe repairable and non-repairable items.	Lecture Explain the basic concept of reliability and give assignments State the difference between reliability and quality control and explain life - cycle conditions of products. Explain reliability as a relative measure and explain probabilistic reliability.	Lecture notes, reference texts and reference. -do-			Short verbal questions on reliability, quality, quality control, reparability and non-reparability. Quiz on reliability, quality, quality control, reparability and non-reparability. Direct the students to explain reliability as a relative measure and explain probabilistic reliability.

General Objectives 2.0 Recognize failure and failure rate						
	2.1 Explain failure, fault and item. 2.2 Classify failures into categories. 2.3 Explain failure causes and failure effects. 2.4 Define failure rate. 2.5 Explain [i] mean time between failure (MTBF), [ii] mean time to failure (MTTF) and [iii] mean time to repair (MTTR). 2.6 Derive the mathematical relationship between reliability and failure rate. 2.7 Derive the mathematical relationship between MTBF, MTTF and failure rate. 2.8 Explain the concept of failure pattern (the bathtub curve). 2.9 Explain mathematical relation of the wear-out failure. 2.10 Explain measurement of mean wear-out life. 2.11 Explain confidence limits for normal	Lecture. Discuss failure, and its relation to basic failure and reliability. Lecture with worked examples	Lecture notes, reference texts and materials. -do-			Ask students to solve problems involving failure, failure rate, mean time between failure (MTBF), mean time to failure (MTTF) and mean time to repair (MTTR). Solve numerical problems with these concepts, give assignments, and quiz.

	distribution.					
General Objectives 3.0 Appreciate the concept of reliability predictions						
	3.1 Explain how to analyze and improve the reliability of systems. 3.2 Describe a fault tree analysis. 3.3 Explain reliability block diagrams. 3.4 Explain the classification of engineering systems 3.5 State the rules for combining probabilities. 3.6 Derive laws of probability relevant to reliability prediction, [i] multiplication rule, [ii] addition rule and [iii] binomial distribution. 3.7 Derive the relation between reliability and MTBF of a series system 3.8 Derive the relation for MTBF of a series system. 3.9 Derive the relation between reliability and MTBF of a parallel system. 3.10 Derive a relation for	Lecture: Discuss the concepts of reliability predictions including probability laws. Lecture with worked examples Derive laws of probability relevant to reliability prediction, multiplication rule, [addition rule and binomial distribution. Derive the relation between reliability and MTBF of a series system Derive the relation for MTBF of a series and parallel system and derive a relation for MTBF of a series and parallel system.	Lecture notes, reference texts and materials -do-			Ask students to explain fault tree and reliability block diagrams. State the rules for combining probabilities. Use these rules to solve problems. Derive laws of probability relevant to reliability prediction. Give relevant numerical examples

	MTBF of a parallel system. 3.11 Drive the relation between reliability of a series - parallel system. 3.12 Drive MTBF of a series-parallel system. 3.13 Explain the redundancy techniques in system design. 3.14 State the classification of redundancy: active redundancy, passive or standby redundancy, and conditional active redundancy. 3.15 State the limitations of redundancy. 3.16 Explain the comparison between reliability improvement using active and passive redundancy. 3.17 Explain redundancy with periodic repair.		Lecture notes and reference texts.			Explain the redundancy techniques in system design. Give the students assignment on the classification of redundancy: active redundancy, passive or standby redundancy, and conditional active redundancy. Lecture with worked examples.
General Objectives 4.0 Outline the causes of component/equipment failure						
	4.1 Explain failure types. 4.2 Describe the classification of causes of component failure. 4.3 Explain [i] environmental stresses [ii] operating stresses [iii] voltage surges, [iii]	Lecture Discuss failure types, the cause of component failure. Discuss failure rate and its relation to	Lecture notes and reference texts.			Ask students to explain failure types and the causes of failure in some basic components, equipment or systems. Give assignments on methods of reducing

	current surges and frequency surges. 4.4 Explain failures in electronic components: capacitors, variable capacitor, resistors, semiconductors, relays, inductors and transformer. 4.5 Describe the methods of reducing component/equipment failure.	basic failure, weighting factors (rating, environmental, temperature etc.)				component/equipment failure including capacitors, variable capacitor, resistors, semiconductors, relays, inductors and transformers.
General Objectives 5.0 Comprehend the concepts of maintainability and maintenance						
	5.1 Explain engineering maintainability and engineering maintenance. 5.2 Describe maintainability functions: [i] exponential distribution, [ii] Rayleigh distribution, [iii] Weibull distribution, [iv] normal distribution and [v] lognormal distribution 5.3 Explain terminologies relating to maintainability: [i] maintenance action,	Lecture Discuss why maintenance is important and relate it to reliability. List out the methods of improving maintainability. Explain maintainability functions: [i] exponential distribution, [ii] Rayleigh distribution, [iii] Weibull distribution, [iv] normal distribution	Lecture notes and reference texts. -do-			Direct students to explain the difference between maintenance and maintainability. Ask students to derive maintainability functions such as exponential distribution, Rayleigh distribution, Weibull distribution, normal distribution and lognormal distribution.

	[ii] active repair time, [iii] logistics time, [iii] administrative time, [iv] mean time to repair (MTTF), [v] maintenance action (repair) time, [vi] maintenance time constraint, [vii] utilization factor [viii] availability [ix] unavailability and [x] reparability. 5.4 Explain system availability and analysis. 5.5 Explain the classifications availability: [i] steady-state availability, [Ii] instantaneous or point availability and [iii] mission availability. 5.6 Explain availability of items in series and parallel configuration. 5.7 Define maintenance 5.8 Explain maintenance 5.9 State the classification **o**f maintenance: [i] corrective maintenance, [ii] preventive maintenance (routine	and [v] lognormal distribution List out the methods of improving maintainability. Explain system availability and analysis. Explain the classifications availability Explain availability of items in series and parallel configuration Explain maintenance. State and explain the classification of maintenance.	Lecture notes and reference texts.			Direct the students to briefly explain the terminologies relating to maintainability Instruct the students to explain system availability and analysis explain the classifications of availability. Ask the students to explain maintenance State and explain the classification of maintenance Ask the students to

		maintenance, preventive replacement, identification of dominant failures, identification of degradation condition), [iii] predictive maintenance. [iv] emergency maintenance (Reactive maintenance, run to fail maintenance), [v] time-based maintenance, [vi] condition-based maintenance, [vii] operational maintenance, and [viii] reliability centered maintenance.		Lecture notes and reference texts.			explain system availability, classification and analysis with numerical examples.
	5.10	State the factors to consider in deciding a maintenance policy: [i] operational requirement [ii] equipment characteristics, [iii] tools and test equipment, [iv] maintenance personnel [v] maintenance instructions and	State the factors to consider in deciding a maintenance policy. Explain methods of	Lecture notes and reference texts.			Direct students to state the factors to consider in deciding a maintenance policy. Instruct the students to explain methods of improving maintainability

	manuals, [vi] spares provisioning [vii] logistics. 5.11 Explain methods of improving maintainability	improving maintainability	-do-			
General Objectives 6.0 Comprehend the concepts of specifications and testing methods						
	6.1 Explain standard specification. 6.2 List and explain the types of specifications: [i] performance specifications, [ii] prescriptive specifications [iii] proprietary specifications and [iv] test specifications. 6.3 State the uses of specification. 6.4 Explain the typical items of information required in specification, 6.5 Describe with an example an equipment specification. 6.6 Explain with examples the components specifications. 6.7 Compare specification	Lecture Discuss the concepts of specification and the testing method with examples. Describe as an example any equipment specification. Explain with examples the components specifications and	Lecture notes and reference texts.			Ask students to explain standard specification and list the types of specifications. Direct students to explain the typical items of information required in specification. Instruct the students to explain the relationship between testing and inspection. Direct the students to explain with examples the components specifications and

	versus cost of an instrument or equipment. 6.8 Explain test methods and describing the various testing methods: [i] prototype testing [ii] pre - production (qualification) testing, [iii] package transportation testing, [iv] production testing and [v] accelerated life testing. 6.9 Explain the relationship between testing and inspection. 6.10 Explain sampling plan and describe the various types of sampling methods: [i] single-sampling plan, [ii] double-sampling plan [iii] multiple-sampling plan, [iv] sequential-sampling plan and [v] acceptance sampling. 6.11 Explain quality and risk decisions.	compare components specification versus cost of an instrument or equipment. Explain test methods and describing the various testing methods. Explain sampling plan and describe the various types of sampling methods. Explain quality and risk decisions.	Lecture notes, reference texts and materials -do-			compare components specification versus cost of an instrument or equipment. Ask the students to explain test methods and describing the various testing methods with relevant examples. Instruct the student to explain sampling plan and describe the various types of sampling methods. Direct the students to explain quality and risk decisions.

HND SLT PHYSICS WITH ELECTRONICS OPTION

LIST OF REQUIRED LABORATORY EQUIPMENT FOR PHYSICS LBORATORY

S/N	ITEMS	QUANTITY	REMARK
1.	Accumulator of various types	10	
2.	Air cell	5	
3.	Air thermometer, constant volume with mercury	2	
4.	Current Balance Apparatus	4	
5.	Electrical equivalent of Heat apparatus	5	
6.	The current balance accessory kit	5	
7.	Lenz law demonstrator apparatus	2	
8.	Bar magnets	20	
9.	Battery charger	1	
10.	Beam/triple balance	5	
11.	Capacitance box	2	
12.	Calorimeters	10	
13.	Compass needle	10	
14.	Digital timer, scaler and frequency counter	2	
15.	Force on a conductor balance	2	
16.	Geiger muller (G.M) tube	2	
17.	Radioactive sources (different types)	1each	
18.	Helium-Neon Laser	2	
19.	Magnetometer	2	
20.	Induction coil	2	
21.	Horse- shoe magnet	2	
22.	Meter Bridge	5	
23.	Wheatstone Bridge	5	
24.	Decade Resistance box (0-1, 111, 110 Ω in 1 Ω	5 each	

	increment)		
25.	Decade capacitance box (100 pF – 11.11 μF in 100 pF steps)		
26.	Latent Heat Apparatus	3	
27.	Linear expansion Apparatus	5	
28.	Micrometer screw gauges	5	
29.	Mirrors (concave, convex of different diameters	10	
30.	Rheostat	10	
31.	Prism glass 60^0, 45^0, 90^0	10 each	
32.	Galvanometers (Assorted: different ranges and ratings)	10 of each	
33.	Jockey	10	
34.	G-Clamp	10	
35.	Three-finger clamp	10	
36.	Joulemeter	2	
37.	Keys (Reversing and tapping)	20	
38.	Lee's Disc Apparatus	2	
39.	Lens (different focal lengths)	3 each	
40.	Optical Bench	3	
41.	Ripple tank apparatus and accessory	1	
42.	Digital stroboscope	1	
43.	Spherometer	2	
44.	Sound level meter	4	
45.	Reed Switch	2	
46.	Electromagnets	2	
47.	Travelling microscope	4	
48.	Newton's Ring Apparatus	1	
49.	Constant volume/constant pressure air thermometer	1 each	
50.	Digital balance	1	
51.	X-ray apparatus	1	

52.	Scanning microscope	1	
53.	Radon gas detector	1	
54.	Refractometer	1	
55.	Polarimeter	2	
56.	Heating mantle	2	
57.	Hot plate	5	
58.	3 – core cable	1 roll	
59.	Measuring cylinders ($100cm^3$, $500cm^3$, $250cm^3$,etc)	2 each	
60.	Beakers ($1000cm^3$, $500cm^3$, $250cm^3$, $100cm^3$, $50cm^3$, etc)	10 each	
61.	Test tubes	20	
62.	Solar cells (different types)	1each	
63.	Centre-tapped Transformer	10	
64.	Pasco radiation sensor	5	
65.	Heat conduction apparatus	2	
66.	Thermal conductivity apparatus	2	
67.	Thermal expansion apparatus	2	
68.	Pasco thermal radiation laboratory kit and accessory	2	
69.	Thermal radiation cube (Leslie's cube)	2	
70.	Thermal cavity laboratory kit and accessory	2	
71.	Thermodynamic kit and accessory		
72.	Window glass.	10	
73.	Stefan-Boltzmann lamp	10	
74.	Adiabatic gas law apparatus	2	
75.	Heat engine/gas law apparatus	2	
76.	Ideal gas law apparatus	2	
77.	Thermal efficiency apparatus	2	
78.	Stress/strain apparatus and accessory	2	
79.	Diffraction grating (transmission type).	5	

80.	Sensor - based diffraction system	2	
81.	Diffraction optics kit	5	
82.	High precision diffraction slits	10	
83.	Pasco radiation sensor	5	
84.	Heat conduction apparatus	2	
85.	Thermal conductivity apparatus	2	
86.	Thermal expansion apparatus	2	
87.	Pasco thermal radiation laboratory kit and accessory	2	
88.	Thermal radiation cube (Leslie's cube)	2	
89.	Thermal cavity laboratory kit and accessory	2	
90.	Window glass.	10	
91.	Stefan-Boltzmann lamp	10	
92.	Adiabatic gas law apparatus	2	
93.	Clamp Meter	4	
94.	Steam generator	10	
95.	Breakers (assorted)	10 each	
96.	Thermometer (assorted with different calibration ranges)	10 each	
97.	Rubber tubing,	5	
98.	Metal rods of aluminum, iron, copper, brass, and steel.	10 each	
99.	Newton's law of cooling apparatus,	5	
100.	Copper calorimeter with a wooden lid and stirrer	10 each	
101.	Open double – walled vessel	5	
102.	Stop clock/watch	20	
103.	Heater/burner	10	
104.	Clamp stand	20	
105.	Rubber stoppers with holes and without holes	10 each	
106.	Double - walled enclosure with cold water between the walls,	5	
107.	Lee's apparatus	5	

108.	Steam generator	10	
109.	Breakers (assorted)	10 each	
110.	Thermometer (assorted with different calibration ranges)	10 each	
111.	Rubber tubing,	5	
112.	Metal rods of aluminum, iron, copper, brass, and steel.	10 each	
113.	Newton's law of cooling apparatus,	5	
114.	Copper calorimeter with a wooden lid and stirrer	10 each	
115.	Open double – walled vessel	5	
116.	Stop clock/watch	20	
117.	Heater/burner	10	
118.	Clamp stand	20	
119.	Vernier calipers	10	
120.	Micrometer gauge	10	
121.	Meter ruler	20	
122.	Wooden dowels of different diameter	5 each	
123.	Liquid nitrogen with Dewar	5	
124.	Thermocouple	10	
125.	Optical rails	10	
126.	Refrigerator	1	
127.	Mercury arc lamp	10	
128.	Measuring scale.	10	
129.	Photoelectric apparatus with a phototube	5	
130.	Tamiya solar panel	5	
131.	Solar constant set	10	
132.	Spectrometer accessory kit	5	
133.	Brewster's angle accessory kit	5	
134.	Precision interferometer accessory kit (with three modes: Michaelson, Fabry-Perot, and Twyman-Green).	3	
135.	Fiber Optics communication kit	3	

136.	Laser communication kit	3	
137.	Michaelson interferometer accessory kit	5	
138.	Coulomb's law apparatus and accessory	3	
139.	Complete e/m apparatus and accessory		
140.	Sodium and mercury light sources	10 each	
141.	Millikan oil-drop apparatus accessory kits	3	
142.	Speed of light apparatus and accessory	3	
143.	Laser speed of light system	3	
144.	Electron spin resonance (ESR) system and accessory kits	3	
145.	Diffusion cloud chambers	2	
146.	Plano-convex and Plano-concave lenses	10 each	
147.	Labvolt circuit board "communication transmission lines" consisting of: 50 kHz step generator with impedance of 10, 25, 50, 100 and 500 Ohms	1	
148.	Dielectric constant measurement trainer (NVIS 6111)	5	
149.	Dielectric materials (Plastic and glass plates)	10 each	
150.	Dynamometer	10	
151.	Deflection magnetometer	10	
152.	Basic coil sets and complete coil sets (primary and secondary coils, air core solenoid)	10 each	
153.	Magnetizer	5	
154.	Dynamometer	10	
155.	Color filters (assorted)	10 each	
156.	Polarizer analyzer kit and accessory	5	
157.	Pulse Height Analyzer	2	

HND SLT PHYSICS WITH ELECTRONICS OPTION
LIST OF REQUIRED LABORATORY EQUIPMENT FOR ELECTRONICS LABORATORY

1.	Analog multimeter	10	
2.	Avometer	10	
3.	Ammeter (different ranges)	10	
4.	Voltmeter (different ranges)	10	
5.	Milliammeterfsigna (different ranges)	10	
6.	Microammeter (different ranges)	10	
7.	Digital multimeter (True RMS multimter, Digital LCR meter)	10	
8.	Cathode Ray Oscilloscope (Single beam)	2	
9.	Cathode Ray Oscilloscope (Double beam)	3	
10.	Signal generators (Audio Frequency)	2	
11.	Signal generators (Radio Frequency)	3	
12.	- Low voltage ac/dc power supply unit (0 - 24 V dc at 0 - 10 A) - Kilovolt power supply (0 - 6 kV dc, 6.3 V/ac, 2 filament source) - High voltage power supply (0-50 V dc at up to 50 mA, 0 - 500 V dc at up to 50 mA, 2 - 7 V ac at up to 3A)	3 3 each 3 each	
13.	Dc power supply (1 Amp at 18 V dc, 0-18Vdc at 0-5 A, 30 V dc, 6A)	3 each	
14.	Triple output power supply (0-30 V dc at 0-3 A)	3	
15.	Logic/Digital trainer	2	
16.	Light Dependent resistor (LDR)	10	
17.	Light Emitting Diodes (Yellow, Green, Red)	5each	
18.	Complete mechanical tool box	1	
19.	Complete electronics tool box	1	
20.	Logic probe/pulser	2	
21.	Bread board	20	
22.	Vero Board	20	

23.	Junction diodes (Assorted)	20	
24.	Transistors (Assorted)	20	
25.	Operational Amplifiers (Assorted)	10 of each	
26.	74 series TTL logic Gates	20	
27.	40 series CMOS logic Gates	10	
28.	Binary counters (Assorted)	10	
29.	Flip – flops	5	
30.	Programmable ICs	10	
31.	Resistors (standard of different values and rating)	10	
32.	555 Timer	5	
33.	Digital ICs	10	
34.	Rectifier unit	5	
35.	Capacitors (Assorted of different values and rating)	50	
36.	Inductors (different values)	10	
37.	Electronic softwares - workbench - Multism - Proteus	1 1 1	
38.	Computer systems	5	
39.	Multimedia projectors	1	
40.	Soldering iron	10	
41.	Solder sucker	10	
42.	Solder lead	1 roll	
43.	Rotary potentiometers (different values)	20	
44.	Resistance apparatus and accessory	10	
45.	RLC circuit kit	5	
46.	Series/parallel circuit kit	5	
47.	Resistor-Capacitor circuit kit	5	
48.	Ac/dc Electronics Laboratory kit and accessory	3	
49.	Ac/dc motor (accessory to variable lab magnet)	5	

50.	Resistance apparatus	5	
51.	Power regulators (78 and 79 series)	5 of each	
52.	Telephone cable	1 roll	
53.	3-core cable	1 roll	
54.	Spectrophotometer accessory kit	3	
55.	Digital Modulation Trainer Kit	3	
56.	Power electronic trainer kits	3	
57.	Quantitative spectroscopes	5	
58.	LED circuit board	10	
59.	Adjustable voltage dc power supply	5	
60.	Demo AS-13 flame test kit	5	
61.	Spectronic 200 spectrometer;	10	
62.	Concentrated food colors in dropper bottles (red, yellow, green, blue);	20 each.	
63.	Incandescent light bulb fixture	10	
64.	Light emitting diodes (LEDs) of several colors	10 each	
65.	Photocathode /ammeter apparatus	5	
66.	Digital voltmeter	10	
67.	Zeeman effect apparatus	5	
68.	Turning – eye vacuum tube (6AF6)	5	
69.	Air-core solenoid	10	
70.	Rheostat, dc ammeter (0 to 5A)	5	
71.	Connecting wires	10 rolls	
72.	Electric furnace	5	
73.	Silicon wafer	10	
74.	Universal measuring amplifier, voltmeter,	10 each	
75.	Adapters, and T-connectors	10 each	
76.	Analogue and digital Gauss/ Telsa meter	5 each	
77.	Strong neodymium magnet 50 grade. dimension 50*20*10 mm,	10 each	
78.	Dc circuit training system	5	

79.	Universal circuit board	10	
80.	Alligator clips and adaptors	10 each	
81.	Banana plug cord sets	10	
82.	Series/parallel battery holders	10 each	
83.	Light bulbs and stand	20	
84.	Light bulbs sockets	10	
85.	Switch sets	10	
86.	Digital RPS (0-30) V	10	
87.	Power supply module EMS 8821	5	
88.	- ac voltmeter module EMS 8426, - ac current meter module EM.S 8428, - resistance module EMS 8311, - inductance module EMS 8321, - capacitance module EMS 8321	5 each	
89.	Digital Storage oscilloscope (DSO)	5	
90.	Analog storage oscilloscope (ASO)	5	
91.	Dual Trace oscilloscope (20 MHz)	5	
92.	Function generator (0.001 Hz – 100 kHz, 0.2Hz – 5 MHz)	5 each	
93.	Multimeter/LCR meter	10	
94.	Multi-function meter,	10	
95.	Three-phase dimmer stat	10	
96.	Field and detector coils	10	
97.	Electromagnetism equipment set	5	
98.	Labvolt circuit board “communication transmission lines”	5	
99.	Tektronix TDS2000 oscilloscope	5	
100.	LAB transmission line demonstrator	5	
101.	Digital logic trainer	5	
102.	8-Bits Microcontroller/Microprocessor Kits (Arduino Kit is handy).	5	
103.	LCD1602 Module visual output device	10	

104.	LED apparatus.	5	
105.	Sine-wave generator	5	
106.	Q-Meter	5	
107.	Q-Meter Adapter	5	
108.	Carey Foster Bridge	4	

LIST OF PARTICIPANTS AT THE HND SCIENCE LABORATORY TECHNOLOGY (PHYSICS WITH ELECTRONICS) CURRICULUM REVIEW WORKSHOP FROM 28TH JUNE, TO 2ND JULY, 2021 AT THE NBTE CONSULT, KADUNA

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